STATE OF CALIFORNIA
The Resources Agency

DEPARTMENT OF WATER RESOURCES
DIVISION OF FLOOD MANAGEMENT

Flood Rapid Assessment Model (F-RAM) Development

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Tables

Appendices

Abbreviations and Acronyms

AEP	Annual Exceedance Probability
ARI	Average Recurrence Interval
BCA	Benefit-Cost Analysis
BCR	Benefit-Cost Ratio
DEM	Digital Elevation Model
DWR	California Department of Water Resources
EAD	Expected (or Estimated) Annual Damages
FEMA	Federal Emergency Management Agency
F-RAM	Flood Rapid Appraisal Method
GIS	Geographic Information System
HAZUS	Hazards US
HEC-FDA	Hydrologic Engineering Center – Flood Damage Assessment
HEC-FIA	Hydrologic Engineering Center – Flood Impact Analysis
NPV	Net Present Value
PV	Present Value
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture

1.1 BACKGROUND

URS has developed a Flood Rapid Appraisal Method (F-RAM) for the California Department of Water Resources (DWR) to assess the benefits (reduction in flood damages) of their levee repair program and prioritize their future repair program.

The F-RAM is a method for the rapid and consistent evaluation of floodplain management measures in a benefit-cost analysis (BCA) framework. Rapidity is required primarily because of the number of floodplain management projects requiring evaluation and because limited funds are available for the evaluation of those projects. Consistency is required to ensure comparability between evaluations.

The F-RAM provides information about the benefits and costs of floodplain management in a timely and cost-effective way. Two key concepts of the F-RAM are:

- **Optimal knowledge** - knowing what facts are worth knowing
- **Appropriate precision -** knowing that precise data are often unnecessary and, in the case of floodplain management, may be impossible to obtain.

The F-RAM is made both rapid and robust by emphasizing that judgment is unavoidable, by structuring and standardizing the form of the analysis, and by organizing the processes of forming judgments.

The F-RAM was developed to determine levee rehabilitation priorities within the San Joaquin River Basin during a task order being undertaken by URS for DWR. At the conclusion of the work, discussions were held with the DWR regarding the merits of including the F-RAM in the "toolkit" of benefit cost models (e.g. Hydrologic Engineering Center – Flood Damage Analysis [HEC-FIA], Hazard US [HAZUS] and Federal Emergency Management Agency [FEMA] flood modules) for evaluating flood mitigation projects. It was subsequently decided that with some modifications and further documentation, the F-RAM would be a valuable addition to the existing toolkit.

1.2 PURPOSE

The purpose of this technical memorandum is to document changes made to the F-RAM to increase its usefulness as a "generic" BCA model that can be used to rapidly assess the benefits and costs of flood mitigation projects. The scope of work included:

- Modification of model parameters
- Modification of input data required to perform an analysis
- Review of model assumptions
- Production of F-RAM user documentation

1.3 STRUCTURE OF THIS REPORT

Within this report, model inputs are modified in Section 2 and model assumptions are reviewed in Section 3. Within Section 4, an overview of the F-RAM documentation is provided and in Section 5 we document the project summary.

Three appendices are provided. Appendix A consists of the user manual, Appendix B outlines the tasks involved with updating the agricultural damage estimates, and in Appendix C, the full and revised F-RAM assumptions are documented.

2.1 OVERVIEW

The F-RAM was developed to assess the benefits and costs of levee rehabilitation in the San Joaquin River Basin. The model was developed as a rapid tool of analysis for use with spatially available data sets, and limited information on the frequency of flood hazards. Within this project, the F-RAM has been modified to provide the user with greater flexibility on the type of data used to calculate flood damages. Specifically, the changes made to the F-RAM were as follows:

- Separating structural and contents damage assessments for industrial and commercial buildings (previously these building losses were combined)
- Including in the F-RAM the option to use HAZUS data where such data are available
- Including in the F-RAM the capability to assess both “potential” flood damages and “actual” flood damages

2.2 INDUSTRIAL / COMMERCIAL BUILDINGS

The F-RAM previously calculated flood damages for industrial and commercial buildings as a combined category of building type. The model was modified so that damages could be specified separately for industrial and commercial buildings.

2.3 HEC-FIA

The F-RAM previously calculated flood damages for residential, commercial, and industrial buildings based on the number of each building type, depth damage curves for different building types, average building and contents values, and the average depth of flooding above floor level for a given flood event. However, the statistical census block data provided as part of the HAZUS model (developed by FEMA), and the Hydrologic Engineering Center – Flood Impact Analysis (HEC-FIA) model that is being developed by the United States Army Corps of Engineers (USACE) can also be used to provide estimates for building and contents damages. HEC-FIA was developed to rapidly assess flood damages from single flood events. This assessment differs from other flood damage assessment models that calculate estimated annual damages (EAD). This model is still in a final testing stage and is yet to be publically released.

HEC-FIA combines several different spatial resources to generate flood damage estimates for any given flood event. It combines hydraulic and hydrological data for a flood event (depth and extent) with a digital elevation model (DEM), and 2000 census data on the number and type of buildings within each affected census block. HEC-FIA has been developed to communicate directly with HAZUS to extract census block data.

A census block is the smallest geographic unit for which the Census Bureau tabulates 100-percent data. Many blocks correspond to individual city blocks bounded by streets, but blocks -- especially in rural areas - may include many square miles and may have some boundaries that are not streets. The most recent data available are from the Year 2000 Census.

The model uses HAZUS average values for regional buildings and USACE depth damage functions (structural, contents, clean-up and debris, and cars) to estimate flood damages. The HEC-FIA model does not assess damages to infrastructure, agriculture or indirect losses.

The F-RAM has been modified so that users have the choice of assessing building damages by keying in losses directly from HEC-FIA (still in development), or using building counts and average flood depths (the method presently in the model).

2.4 ACTUAL VS POTENTIAL DAMAGES

The F-RAM has been developed to calculate both actual and potential flood losses. The mean values of damages for residential and non-residential buildings that are calculated using depth damage curves represent the “potential” level of damage that would occur if no remedial action of any kind were undertaken. However, in most instances many property owners have time to make some preparations aimed at reducing contents damages. For example, they can take valuable items or cars away from the property, or raise valuable objects to a height above the likely level of inundation. Consequently, it is necessary to estimate the likely “actual” level of damages which would occur in each flood event. This can be expressed as a ratio of actual:potential damages.

The level of damages which can be avoided is a function of available flood warning time and the prior flood experience of those at risk. People are less likely to prevent damage if they are inexperienced, uninformed, or if they receive no warning.

Research undertaken in Australia concluded that even with no available warning time, internal residential damage is reduced to about 85 per cent of potential damage, irrespective of flood awareness, i.e. most people remember to do ‘something’ to save their possessions (Water Studies 1995). Smith *et al* (1990) observed the following ratios of actual:potential damages for major floods in Australia during the 1970s and 1980s (see Table 2-1).

Table 2-1 Effect of warning time and experience on damages

Flood	Warning time	Experience of flooding	Ratio of actual:potential damages
Brisbane	30 hours	Rare flooding, unaware hazard	0.90
Bairnsdale	20hours	Frequent flooding, well prepared	0.45
Eugowra	7 hours	Frequent flooding, well prepared	0.35
Forbes	70 hours	Frequent flooding, well prepared	0.30
Inverall	10 hours	Rare flooding, unaware hazard	0.70
Nyngan	5 hours	Rare flooding, unaware hazard	0.85
Queenbeyan	6 hours	Rare flooding, unaware hazard	0.81
Geelong	3 hours	Rare flooding, unaware hazard	0.75
Lismore	12 hours	Frequent flooding, well prepared	0.40
Traralgon	6 hours	Frequent flooding, well prepared	0.60
Sydney	3 hours	Rare flooding, unaware hazard	0.80

For the purposes of the F-RAM, we have defined ‘experienced’ as having experience of floods within the last 5 years and adopted the following ratios of actual:potential damages (see Table 2-2).

Table 2-2 Proposed ratios of actual:potential damages

Warning time	Experienced community	Inexperienced community
Less than 2 hour	0.8	0.9
2 to 12 hours	Linear reduction from 0.8 at 2 hours to 0.4 at 12 hours	0.8
Greater than 12 hours	0.4	0.7

Potential losses can include damage to business inventory. If the flood reaches above floor level, then any inventory stored on the floor is subject to damage from flood waters. However, actual losses may be much less if warning time is sufficient and business operators have enough time to relocate the inventory. Also, if business operators have flood experience, they will have a better idea of what needs to be done when they are warned that a flood is imminent. Another example is that, if enough warning time is given, families may be able to relocate their valuables to the second floor or use sandbags to protect their properties from damage.

Thus, actual losses can be much lower than potential losses if the population affected has previous flood experience and/or if there is sufficient warning time before the flooding event begins. This distinction shows that developing an adequate warning system can do much to mitigate the costs of flooding where a levee breech is due to overtopping. However, for a “sunny day" levee breech, flood warning time or the experience of the community are unlikely to have any ability to reduce potential losses.

The difference between actual and potential losses has now been made explicit in the F-RAM to show the effect of an adequate warning system. This functionality of the model enables project benefits to be achieved from non-structural projects.

3.1 OVERVIEW

Within this section, model assumptions used to assess agricultural damages, damage to roads and infrastructure, and damages to buildings and contents were reviewed and updated as necessary.

3.2 AGRICULTURAL DAMAGES

The F-RAM includes damages for agriculture based on different crop types and periods of inundation. The values used were taken from the USACE Comprehensive Study[1] and were in 1999 U.S. dollars. There were two areas in agriculture damages that required updating. The first was to update the dollar values to present day dollars. The second was to check whether the crops modeled remain appropriate, or whether different crops should be modeled.

3.2.1 Updating to Present Day Dollars

To update the damage costs estimates to present day dollars, we acquired prices paid and prices received indices from the US Department of Agriculture for various farm product categories. The latest data that was available was for the 2006 year, from the 2007 published report. Thus the updated estimates are in 2006 U.S. dollars. Agricultural production in the model was matched with the appropriate index categories for the prices received categories. A composite category for all production costs, etc. was used to index all direct production costs. Finally, the indexed damage cost estimates were integrated into the F-RAM. See Appendix B for detailed information on the updating process.

The crop budget data calculates a weighted average annual flood damage estimate, based on income, variable costs not expended, probability of flood in that month and percent of damages that would occur if there was a flood. Land clean-up and rehabilitation costs are added as a fixed cost to each estimate. In addition, if flooding persists for longer than a critical threshold (typically five days for permanent tree crops), a crop-specific establishment cost is added, to replace the damaged crop.

The revised crop damage estimates used are shown in Table 3-1. In revising these agricultural damage estimates, some numbers reduced, namely cotton at minus 14 percent, while other costs increased, namely rice at 20 percent.

[1] The Comprehensive Study took data from the UC Coop extension data, which can be found at http://coststudies.ucdavis.edu/current.php

Table 3-1 Crop product categories and cost estimates.

PRODUCT	Weighted Ave Annual Damages	Establishment Costs	Land Cleanup & Rehab	Total (<5days)	Total (>5days)	% Change <5days
Corn	$48	$0	$246	$293	$293	20%
Rice	$227	$0	$243	$471	$471	27%
Walnuts	$585	$5,284	$243	$828	$6,112	9%
Almonds	$1,618	$3,514	$243	$1,862	$5,376	12%
Cotton	$301	$0	$246	$547	$547	-14%
Tomatoes	$1,015	$0	$235	$1,250	$1,250	13%
Wine Grapes	$3,241	$3,240	$235	$3,476	$6,716	16%
Alfalfa	$250	$246	$243	$493	$739	-2%
Pasture	($15)	$82	$272	$257	$339	25%
Safflower	$164	$0	$241	$405	$405	-6%
Sugar Beets	$313	$0	$262	$575	$575	-6%
Beans	$111	$0	$246	$356	$356	14%
Other			$246	$246	$246	

Data updated from USACE 1999 Comprehensive Study

3.2.2 Crop Appropriateness

Twelve crops are modeled in the F-RAM based on crop data that was available from the USACE Comprehensive Study. These were: corn silage, rice, walnuts, almonds, cotton, processing tomatoes, wine grapes, alfalfa hay, pasture, safflower, sugar beets, and beans (common dry varieties). Within this project, we sought to determine whether these existing crops remained representative of the crops grown in the study area.

Land use within the study area was identified using spatial geographic information system (GIS) datasets from the DWR. The DWR dataset maps over 75 types of agricultural land use within California. The dataset used is almost 10 years old, so it will not capture any more recent land use trends. From our analysis of this data, no changes to the agricultural crops modeled in the F-RAM were considered necessary.

3.3 ROADS AND INFRASTRUCTURE

The F-RAM estimates damages for roads and road infrastructure using unit loss estimates per length of road inundated. The values used are weighted average damages and assume that some roads will need to be repaired, while other roads will incur no damages. The damage estimates used in the model have been taken from studies of flooding from non-levee breaching flooding events in Australia. The damage estimates include both immediate damages to roads and bridges as well as increased maintenance costs associated with an increased onset of road deterioration. Within this project we sought to identify “other” values for damage to infrastructure that could be used within the F-RAM. As part of this task, a review of literature was undertaken. We also accessed data from FEMA to determine whether this information could be used to develop standard damage estimates for roads.

The standard values presently used in the F-RAM are shown in Table 3-2.

Table 3-2 Estimated Damages to Roads

Type of Road	Cost of Damages $/mile
• Cost per mile of highway inundated	• $250,000
• Cost per mile of major road inundated	• $100,000
• Cost per mile of minor road inundated	• $30,000
• Cost per mile of gravel road inundated	• $10,000

3.3.1 Literature Review

A literature search returned several studies that estimate the cost per unit length of road or road infrastructure; however, none of these estimates were based on research undertaken in the US.

Several papers containing road cost estimates were reviewed. One paper (Gupta) estimated direct damage to infrastructure at U.S. $66,667/km (or $107,000/mile). However, it is unclear whether this cost is per kilometer of road inundated, or per kilometer of road damaged. .In addition this cost reflects the damage assessment for areas surrounding the Mekong River in Asia, and costs of labor are likely to be lower in this area compared with the US, as are the standards for road construction.

The approach used in New Zealand is to estimate flood damage repair costs at 7 percent of the regular maintenance program (Government of New Zealand 2004). The total maintenance costs (including renewals) are roughly NZ $15m (U.S. $10m)[2], or:

- NZ $15,500/km (U.S. $17,000/mile) for urban sealed roads,
- NZ $10,500/km (U.S. $11,000/mile) for rural sealed roads,
- NZ $14,400/km (U.S. $15,000/mile) for urban unsealed roads, and
- NZ $5,600/km (U.S. $6,000/mile) for rural unsealed roads.

The Government of Scotland (2005) estimates costs of GBP 2,000,000/km (or U.S. $5,858,000/mile)[3] to repair roads damaged by flooding. However, while not directly stated, this estimate appears to be an estimate of the cost per length of road repaired, as opposed to the cost per length of road inundated. The difference is that only a portion of road inundated is likely to need significant repair. In addition, this number includes the increased travel costs due to traffic disruptions from flooding.

[2] New Zealand data converted using the 2004 average exchange rate of 0.6643 from the Federal Reserve website.
[3] Scottish data converted using the 2005 average exchange rate of 1.82 from the Federal Reserve website.

Saelthun (1999) estimates the direct damage to public roads (country and national routes) in Norway are about NOK 306,000/km (or U.S. $63,162/mile)[4]. Indirect costs were reported as difficult to estimate, but in the order of magnitude of the direct costs. These estimates again seem to represent the cost per length of road repaired and not the cost per length of road inundated.

Table 3-3 Summary of findings from Road Damage Literature Review

Study	**Cost/unit length of road/bridge**	**US $ /unit of road**
Hoes (2005)	€100,000/ha	$135,000/ha
Gupta	U.S. $66,667/km	$107,000/mile
Saelthun (1999)	NOK 306,000/km	$63,162/mile
Govt of NZ (2004)	Flood Damage Repair = 7% of Regular Maintenance Programme	7% of maintenance
Govt of Scotland (2005)	GBP 2,000,000/km (this may be for the actual length of road needing repair, not an average cost for all roads)	$5,858,000/mile

3.3.2 Analysis of FEMA Road Damage Estimates

FEMA provides disaster assistance funding after a natural disaster is declared and maintains digital records of all funding provided. We analyzed some of this data to determine if anything could be concluded about road damage estimates in California. Data was obtained from four major flooding events in California from December 2004 to April 2006. This data includes information on the:

- Flooding event
- Applicants that received FEMA funding for repair work funds
- Amount granted to each applicant
- Category of repair work for which the grant was used
- A short description of the repair project

From the data, we were able to estimate the cost of damages to roads and bridges to each applicant (usually a city or county) caused by each flooding event (Table 3-4).

[4] Norwegian data converted using the 1999 average exchange rate of 7.8 from the Federal Reserve website.

Table 3-4 Flood Damage Grant Application Data

Flood Event #	**1577**	**1585**	**1628**	**1646**
Declared Disaster Dates	Dec 27, 2004- Jan 11, 2005	Feb 16, 2005 – Feb 23, 2005	Dec 17, 2005 – Jan 3, 2006	Mar 29, 2006 – Apr 16, 2006
Flood Duration (d)	16	8	18	19
Total Grants Paid	$89,241,825	$30,918,462	$65,263,231	$26,493,879
Maximum Individual Grant	$20,611,660	$9,013,891	$5,345,551	$4,937,298
Mean Individual Grant	$547,496	$461,470	$375,076	$407,598
Median Individual Grant	$65,101	$58,200	$45,558	$60,458

The duration of the floods range from 8 days to 19 days, and the total amount of damages claimed per flood range from $30,918,462 to $89,241,825 with the mean grant per applicant ranging from $375,076 to $547,496. The data is highly skewed to the upper values, as the median range is much lower, from $45,558 to $65,101. In other words, the bulk of the flood claims for infrastructure are below $65,000, but there are a few large claims that substantially skew the mean upwards.

The data analyzed did not include information on the spatial location, classification, length or condition of road or bridge damaged. In addition, no information could be ascertained on the extent of flooding for each declared disaster. This information is necessary to estimate the cost of damage to infrastructure per length of road inundated.

3.3.3 Conclusions

Roads and bridges vary in their materials and designs. The vulnerability of roads and bridges to flood varies drastically depending on the type of components, their age, their design and condition. When a levee breach is involved, the location of the road relative to the breach is important in estimating damages. Within the US, engineers and economists have preferred to make facility-specific estimates of damages based on historical damage data and professional judgment rather than develop standard values for use in benefit cost models. For this reason, the standard values presently used in the F-RAM have been kept, and a methodology proposed whereby US specific standard values could be developed.

3.3.4 Proposed Approach to Develop Road Damage Estimates

No “standard” flood damage estimates per unit of road inundated are presently available in the US. For this reason, we have proposed an approach that could be used to determine these costs based on FEMA data on actual road damage applications. The following approach using GIS and a digital elevation model (DEM) is proposed:

- Access FEMA flood damage data for Roads in California and ensure that data is collected for the:

- latitude and longitude of the site of each damage area;
- lengths of roads or bridges that were damaged;
- classifications of the roads or bridges that were damaged;

- Use the frequency of the flood event to estimate the area and elevation of flooding that occurred, and the total lengths and classifications of roads and bridges that were inundated.
- Use the grant application data for the cost of repairing roads and bridges to estimate standard damages per length of road inundated.

3.4 DEPTH DAMAGE CURVES

Depth damage curves demonstrate the relationship between the depth of the flood relative to the first finished floor level of buildings and the damage caused to the structures and contents of the affected buildings. Damages are typically expressed as a percentage of depreciated building replacement value. If flood waters reach below the first finished floor level of the building, then only limited structural damage is assumed to occur to the building. If flood waters reach above the first floor level, then damage estimates will include damage to both contents and structures. Within this project, the depth damage curves used in the F-RAM were reviewed to see if any more recent curves had been developed by the USACE, FEMA or other agencies.

The depth damage curve estimates used in the previous F-RAM for residential buildings with basements came from the USACE 2003 report on generic depth damage curves[5]. All other depth damage curves that were used came from the USACE Sacramento and San Joaquin Rover Basins Comprehensive Study[6] and Ford (2005). These include depth damage curves for: residential buildings, one story, no basement; residential buildings, two or more stories, no basement; farm homesteads, mobile homes; public buildings; industrial buildings; and, commercial buildings.

The USACE, Sacramento District, is currently working on updating depth damage curve estimates for the Folsom dam project. This report contains estimates on depth-damage for a variety of building uses, including office buildings, commercial retail, restaurants, light industry, warehouses, hospitals and others. The estimates were generated by eliciting several experts' opinions. The latest draft was completed in May 2007, but it is unknown when the final report will be published.

Also, a group at the URS Gaithersburg office is currently working on estimating depth damage curves for 20 different categories of non-residential use buildings. The development of these estimates is in progress and they are expected to be available towards the end of August 2008. It is recommended that the F-RAM depth damage curves be updated when these new estimates become available.

[5] Report with subject line "Economic Guidance Memorandum 04-01, Generic Depth-Damage Relationships for Residential Structures with Basements" dated 10 October, 2003
[6] Available at: http://www.compstudy.net/

4.1 OVERVIEW

The F-RAM provides a method for evaluating the costs and benefits of flood mitigation projects in the DWR levee repair program. Rather than provide the most accurate damage estimates, it was developed to assist the DWR to rapidly identify priority sites for management.

It considers the costs of projects (levee repair work) and the benefits to society of reduced damage from flooding events. The damages considered include residential, commercial and industrial building damages, road damages and agricultural damages. The F-RAM is a rapid, consistent and transparent tool for conducting a BCA.

The F-RAM has been developed in Microsoft Excel. It relies on user-entered data for the flood frequency, levee fragility and consequences of flooding before and after flood mitigation work. The model calculates the benefit-cost ratio (BCR) and Net Present Value (NPV) of the work.

The F-RAM consists of 17 worksheets as described below:

1. Menu. The Menu page can be used to navigate the rest of the document. The menu page contains six buttons for ease of navigation that allows the user to: read the instructions; enter project information; enter special cases; view the cost-benefit analysis; view the stage damage graph; and view the EAD graph.
2. Instructions. The Instructions page contains general information on the input space and output page of the F-RAM.
3. Model Map. The Model Map gives a brief description of the worksheets in the model.
4. Inputs. The Inputs page is the page where user inputs are entered. The user manual (Appendix A) provides detailed information on how and where to enter information.
5. BCA Summary. The BCA Summary is the main output page. It provides information on the costs, the benefits with and without the project, annual benefits, the present value (PV) of the future stream of benefits, the discount rate and length of time used to calculate the PV, the NPV, and the benefit-cost ratio. In addition, it includes a sensitivity analysis for changes in the discount rate.
6. Assumptions. The Assumptions page documents all the assumptions used in the model. It includes information on the cost of damage per unit to various types of buildings, agricultural crops, and roads.
7. Depth Damage Curves. The Depth Damage Curves page documents the curves that are used to calculate damages to buildings and contents.
8. Residential. The Residential page uses the assumptions and user-entered inputs to calculate damage to residential properties.
9. Commercial & Industrial. The Commercial & Industrial page uses the assumptions and user-entered inputs to calculate damage to commercial and industrial properties.
10. Agricultural. The Agricultural page uses the assumptions and user-entered inputs to calculate damage to agricultural crops.
11. Roads. The Roads page uses the assumptions and user-entered inputs to calculate damage to various types of roads.

12. Special Cases. The Special Cases page is provided in case the user has additional damages to include that are not included in the standard model.
13. Without Project EAD. The Without Project EAD page summarizes the damage costs before any works are implemented. It expresses the flood damage estimate as the EAD.
14. Graph Data. This page assembles the information that is used for the Stage v Damage and Estimated EAD graphs.
15. With Project EAD. The With Project EAD page summarizes the damage costs after works have been implemented. It expresses the flood damage estimate as the EAD.
16. Stage v Damage. The Stage v Damage page shows a graph of the dollar damages incurred plotted against the water surface elevation.
17. Loss Probability Curve. The Loss Probability Curve page shows a graph of the actual loss probability curves. That is, dollar damages incurred plotted against the annual exceedance probability (AEP) for each modeled flood event. Both the with- and without- project loss probability curves are shown.

A detailed user manual is included in Appendix A.

4.2 LIMITATIONS OF THE F-RAM TOOL:

The flood damages F-RAM developed for this task is a rapid, transparent, and defensible model that the DWR can use to aid in the prioritization of levee repair works.

It should be stressed that this is an economic model and should not be the only factor driving the investment decision. Considerations such as public safety, equity, and other political factors, must also be weighed up and the outputs of this model should therefore form only one component, albeit an important one, of the overall decision-making process.

The F-RAM is a relative tool rather than absolute tool. It will identify the relative priorities between different potential sites for flood mitigation; however, the absolute estimates of flood damages should be treated with caution when negotiating investment cost sharing. If federal cost-sharing is required, it is likely that further analysis will be required using federally approved flood damage models.

The purpose of this technical memorandum was to document changes made to the F-RAM to increase its usefulness as a “generic” BCA model that can be used to rapidly assess the benefits and costs of flood mitigation projects.

During this project, the model parameters were modified to meet the needs of the flood repair program. The model was changed to separate industrial building damage estimates from commercial building damage estimates, and to enable damage estimates to be input from the HEC-FIA model that is in development by the USACE at Davis.

A literature review for damages to roads and bridges was conducted and FEMA claim data reviewed, but insufficient information was obtained to change the standard values for damages to roads that are included in the model. Model assumptions for agricultural flood damage estimates were indexed to 2006 prices. Depth damage curves were reviewed; however, the review concluded that no change to these numbers was required at this stage.

Finally, a user manual for the F-RAM was developed.

Bugden, G.B. (1997), *Urban Salinity in Wagga Wagga*, paper presented to ABARE's Outlook 97 Conference, Canberra.

David Ford Consulting Engineers (2005), Urban flood scenario: Sacramento area levee breach scenario, report prepared for California Department of Water Resources, December 5th 2005.

Government of New Zealand. 2004. *Unsealed Road Maintenance*. June 22. http://www.wdc.govt.nz/agendas_online/WS_23062004/A607506.html

Government of Scotland. 2005. *Scoping Study into the Cost of Flooding Using the August 2004 event as a case study Final Report*. Appendix D: Economics Analysis. May 25. http://www.scotland.gov.uk/Publications/2005/05/17151735/18048

Gupta, Ashim Das, Mukund Singh Babel, Pham Ngoc. 2003. *Flood Damage Assessment in the Mekong Delta, Vietnam*. Asian Institute of Technology, Thailand. http://www.wrrc.dpri.kyoto-u.ac.jp/~aphw/APHW2004/proceedings/FWR/56-FWR-M167/56-FWR-M167.pdf

Hoes, Olivier. 2005. *Risk assessment to quantify the interaction between land use and water management*. ERSA-congress, Amsterdam. http://www.iiasa.ac.at/Publications/Documents/IR-00-047.pdf

Saelthun, Nils Roar. 1999. *Risk Analysis Project within the Norwegian HYDRA Flood Research Programme.* Norwegian Institute for Water Research. September. http://www.ymparisto.fi/download.asp?contentid=16881&lan=en

URS (2006) Development of a Model to Prioritize Flood Mitigation Works Final Report. Prepared for Melbourne Water.

USACE (2002) Sacramento and San Joaquin River Basins Comprehensive Study, Appendix F Economics Technical Documentation.

USACE (2003) Economic Guidance Memorandum (EGM) 04-01, Generic Depth-Damage Relationships for Residential Structures with Basements.

Appendix A

Flood Ram User Manual

INTRODUCTION

URS has developed the F-RAM, a Microsoft Excel-based Benefit-Cost Analysis model, for the DWR. The DWR is responsible for appraising levee-repair projects where they have jurisdiction. The F-RAM is a tool that provides rapid, systematic and transparent project appraisal.

While this tool and methodology are extremely useful in supporting flood mitigation decision-making, the methodology presented is intended to provide 'rapid appraisal' only. Undertaking a rapid appraisal using the F-RAM is not a substitute for undertaking a detailed assessment before commissioning any particular project.

Within this appendix, a user manual for the F-RAM is presented to provide assistance to potential users and describe the model's intended use.

OPENING THE MODEL

To commence a project appraisal, open a new copy of the model template file and save it under a new name. Set the security level in Excel to low or medium (Tools > Macros > Security) and close the document. Reopen the document and enable macros upon opening the document.

The F-RAM template is contained in a single file, and a separate copy of it is required for each individual project being evaluated. The model template is contained in the file: "Blank F-RAM.xls".

It is recommended that a naming convention be developed by users for saving each copy of this file, for ease of reference in the future. For example, this naming convention could be: "[Levee Name] [Levee Reach Number] [Appraisal Date].xls". Each new copy of this file created should be saved in the same directory for future reference.

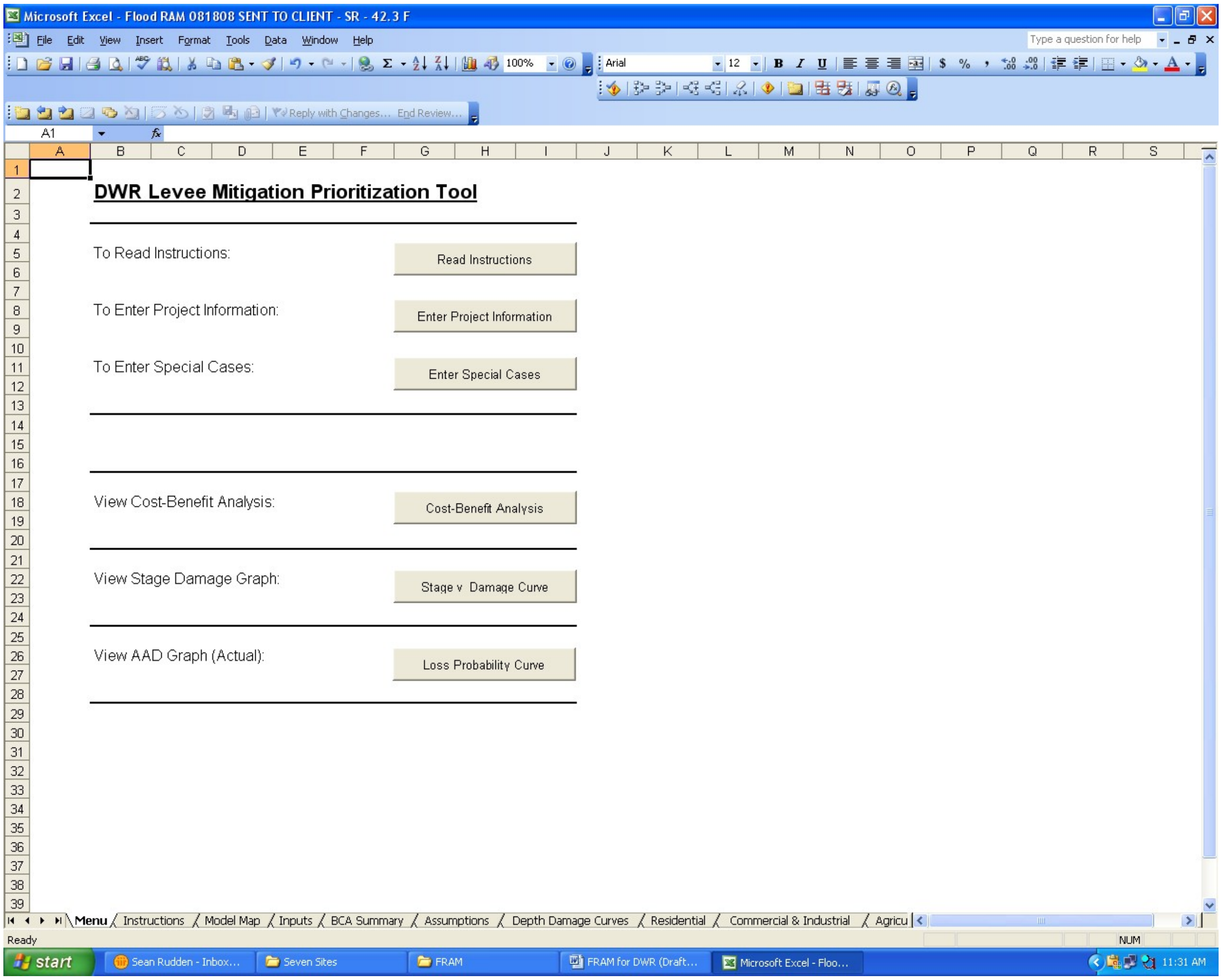
NAVIGATING THE MODEL

Use the first worksheet, titled "Menu" to navigate the rest of the model. To begin entering information, click on the "Enter Project Information" button. To read the instructions, click on the "Read Instructions" button. To enter information on special cases, click on the "Enter Special Cases" button.

The first worksheet in this model is a menu allowing easy navigation of the rest of the model (see Figure A-1). Buttons have been provided to navigate between pages that require user input or provide output. At the top of each of these pages is a "Return to Menu" button to return to this main menu.

The model contains a number of other worksheets that are necessary to perform background calculations in determining benefits and costs. The purpose of each of these worksheets is described in the "Model Map" worksheet.

Figure A-1: F-RAM - Main Menu



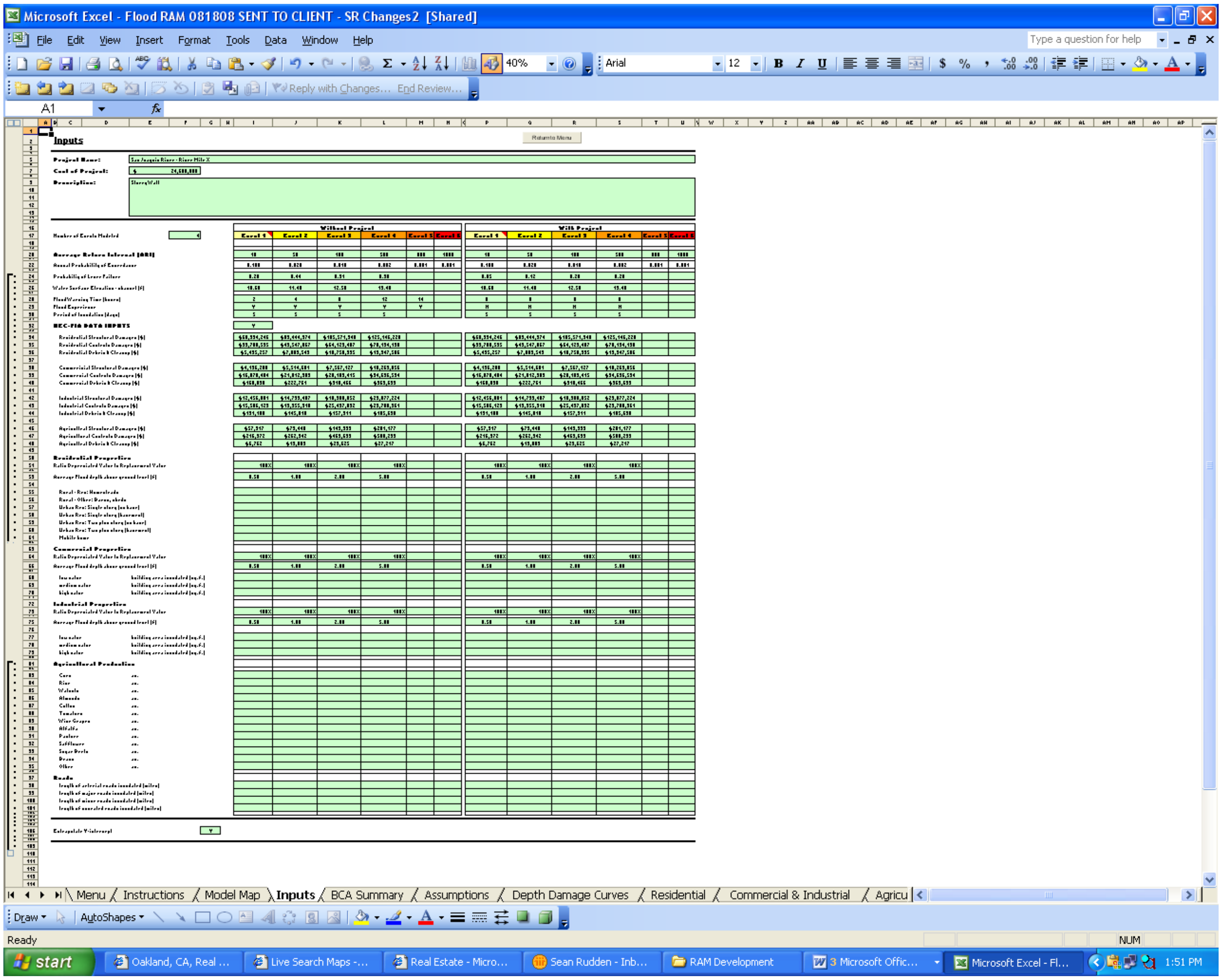
ENTERING STUDY AREA INFORMATION

All of the user-entered data required to complete the project appraisal are entered in the “Inputs” worksheet. This worksheet, shown in Figure A-2, allows data to be entered for a number of required fields for both the with- and without-project cases.

The input required in each of these fields is described in detail below.

User input is only required for cells highlighted in green, as shown in Figure A-2.

Figure A-2: F-RAM - Inputs Page



Project Name

Enter the name of the project being evaluated.

The name should be meaningful to the user and to anyone who may be viewing the workbook or the output of the workbook, either presently or in the future.

Cost of Project

Enter the present value of the total cost of the project being evaluated (in dollars).

The present value of the cost of the project is a single number that encompasses the future stream of cash outflows associated with the project which includes both capital and operations and management costs. Any future year payments should be discounted to account for the time-value of money.

Description

Enter a description of the project being evaluated.

A description of the project being evaluated is useful to clarify what exactly the project involves, especially if other parties might refer to this evaluation in the future.

Number of Events Modeled

Enter the number of flood events being modeled.

The number of events modeled (i.e. how many different flood frequencies are being considered) is necessary so that the model can incorporate data from the correct number of flooding events into the cost-benefit calculations.

Average Recurrence Interval (also Annual Recurrence Interval)

Enter the average recurrence interval (in years) for the events being evaluated.

The Average Recurrence Interval (ARI) is the average time interval (in years) between occurrences of a hydrologic flood event. The model allows up to six flood events to be entered.

Probability of Levee Failure

Enter the probability that the levee would fail in each of the flooding events considered.

The estimated probability of levee failure with- and without-project for each event is required. A value of “0” would reflect no probability of failure, while a value of 1.0 would reflect certain failure. A value of 1.0 would be entered where the levee would be over-topped during a flood event.

Water Surface Elevation – Channel

Enter the depth of the levee channel water above sea level (in feet).

This datum is used to produce the stage damage graph only.

Flood Warning Time

Enter the amount of warning time (in hours) that is given (i.e., the amount of time between when notice of an impending flood is received and when the flood waters begin to cause damage).

Flood warning time is a significant factor in determining the relationship between potential and actual damages. Flood warning time is only likely to be of interest where a levee is to fail due to overtopping. In all other instances where the levee fails, zero flood warning time should be assumed.

Flood Experience

Enter “Y” if residents have had prior experience with a flood of each magnitude in the last 5 years. Enter “N” otherwise.

Flood experience is another significant factor in determining the relationship between potential and actual damages. In this case, “Flood Experience” refers to a yes or no question: “Do the majority of people in the study area have tangible experience of flooding in that area?” Given that memories fade over time, we believe that generally this question can only be answered ‘yes’ if there has been a flood event of magnitude during the last 5 years. Answering this question requires historical knowledge of the Study Area, or a brief survey of residents.

HEC-FIA Data Inputs

Enter “Y” if HEC-FIA data is going to be used as an input to the model or “N” otherwise.

Data obtained from the HEC-FIA model gives damage estimates for agriculture, commercial, education, government, industrial, religious, residential and occasionally untitled properties. The education, government and religious structures need to be included with the commercial structure damages while the untitled properties should be included with the residential structure damages. Damage values of interest include the structural, content and car damages with each estimate having their own required input value in the model.

HEC-FIA Data Inputs—Structural Damage

Enter data on building structural damage from the HEC-FIA model if using HEC-FIA data.

HEC-FIA Data Inputs—Contents Damage

Enter data on building contents damage from the HEC-FIA model if using HEC-FIA data.

HEC-FIA Data Inputs—Debris and Cleanup

Enter data on debris and clean-up costs from the HEC-FIA *model if using* HEC-FIA *data.*

The HEC-FIA model does not specifically give data on debris and clean-up costs; however it does give a value for car damage which is the value that is inputted here.

Period of Inundation

Enter the number of days each event is expected to last.

Duration of flooding for greater than 5 days results in greater levels of economic damage for various agricultural crop damage estimates.

Residential Properties—Ratio of Depreciated Value to Replacement Value

Enter the ratio of depreciated value to replacement value of residential properties, in percent if not using HEC-FIA data.

The ratio of depreciated value to replacement value for residential properties is necessary because the damage cost per square foot for residential properties is calculated using replacement value. Thus, if properties have depreciated since construction (enter a value less than 100%), then the damage costs will be lower than the replacement value. These values can be obtained in the HAZUS model.

Residential Properties—Average Flood Depth Above Ground Level

Enter the expected depth of the flood above ground level (in feet), on average if not using HEC-FIA data.

This is an estimate of the average height of inundation above ground level. The model uses this number and an assumption on the height of the first floor above ground level, to determine the depth of flooding above floor level for different buildings.

Residential Properties—Number of Properties Flooded

Enter the number of residential properties of each type that are expected to be affected by the flood if not using HEC-FIA data.

The damage estimation methodology prepared by URS provides methods for assessing a variety of housing types. The numbers of properties of each type inundated are entered in the appropriate category: Rural-residential (homesteads); Rural-other (barns, sheds); Urban Residential-single story (no basement); Urban Residential-single story (basement); Urban Residential-two plus story (no basement); Urban Residential-two plus story (basement); and Mobile homes. The model uses standard assumptions for the average size, first floor elevation and value of different building types to estimate damages to buildings and contents. For these assumptions see the "Assumptions" worksheet.

Commercial Properties— Ratio of Depreciated Value to Replacement Value

Enter the ratio of depreciated value to replacement value of commercial properties, in percent.

The ratio of depreciated value to replacement value for commercial properties is necessary because the damage cost per square foot for commercial properties is calculated using building replacement value. If properties have depreciated since construction (enter a value less than 100%), then the damage costs will be lower than replacement value. These values can be obtained in the HAZUS model.

Commercial Properties—Flood Depth Above Ground Level

Enter the expected depth of the flood above ground level (in feet), on average if not using HEC-FIA data.

This is an estimate of the average height of inundation above ground level. The model uses this number and an assumption on the height of the first floor above ground level, to determine the depth of flooding above floor level for different commercial buildings.

Commercial Properties—Area Inundated

Enter the area (in square feet) of each type (low, medium, or high value) of commercial property that is expected to be inundated by the flood event if not using HEC-FIA data.

Damages to commercial buildings are particularly difficult to estimate. The user must determine the total floor area inundated for low value, medium value, and high value enterprises. The model has standard assumptions for the value of low, medium and high value commercial buildings on a per square foot basis as well as the first floor elevations. For these assumptions see the “Assumptions” worksheet.

Industrial Properties— Ratio of Depreciated Value to Replacement Value

Enter the ratio of depreciated value to replacement value of industrial properties, in percent if not using HEC-FIA data.

The ratio of depreciated value to replacement value for industrial properties is necessary because the damage cost per square foot for industrial properties is calculated using building replacement value. If properties have depreciated since construction (enter a value less than 100%), then the damage costs will be lower than replacement value. These values can be obtained in the HAZUS model.

Industrial Properties— Flood Depth Above Ground Level

Enter the expected depth of the flood above ground level (in feet), on average if not using HEC-FIA data.

This is an estimate of the average height of inundation above ground level. The model uses this number and an assumption on the height of the first floor above ground level, to determine the depth of flooding above floor level for different commercial buildings.

Industrial Properties—Area Inundated

Enter the area (in square feet) of each type (low, medium, or high value) of commercial property that is expected to be inundated by the flood event if not using HEC-FIA data.

Damages to industrial buildings are particularly difficult to estimate. The user must determine the total floor area inundated for low value, medium value, and high value enterprises. The model has standard assumptions for the value of low, medium, and high value industrial buildings on a per square foot basis as well as the first floor elevations. For these assumptions see the “Assumptions” worksheet.

Agricultural Production

Enter the number of acres of farmland for each type of agricultural crop that is expected to be affected by each flood event.

Agricultural production damage assumptions are based on estimates of monthly variable cost, income, and the probability of flooding.

Roads

Enter the length (in miles) of each type of road (highways, major, minor, unsealed) that is expected to be inundated.

Roads are the main infrastructure affected by flooding. Four distinct classifications of roads are identified in the damage estimation methodology: highways, major, minor and unsealed.

Special Cases

If there are any damages from flooding that are not covered by the categories included in the "Inputs" worksheet, enter them in the "Special Cases" worksheet.

For each additional cost, enter a brief description of the case and the expected cost (in dollars) of each case due to each flood event both pre- and post-project.

The only inputs not entered into the "Inputs" worksheet are those for special cases. If this worksheet is used, dollars damages entered should be the result of a detailed site survey by a trained loss assessor.

VIEWING APPRAISAL RESULTS

To view the results of the appraisal, click on the "Cost-Benefit Analysis" button from the "Menu" worksheet.

The results of the project appraisal are aggregated onto a single worksheet titled "BCA Summary", shown in Figure A-3. This sheet brings together the:

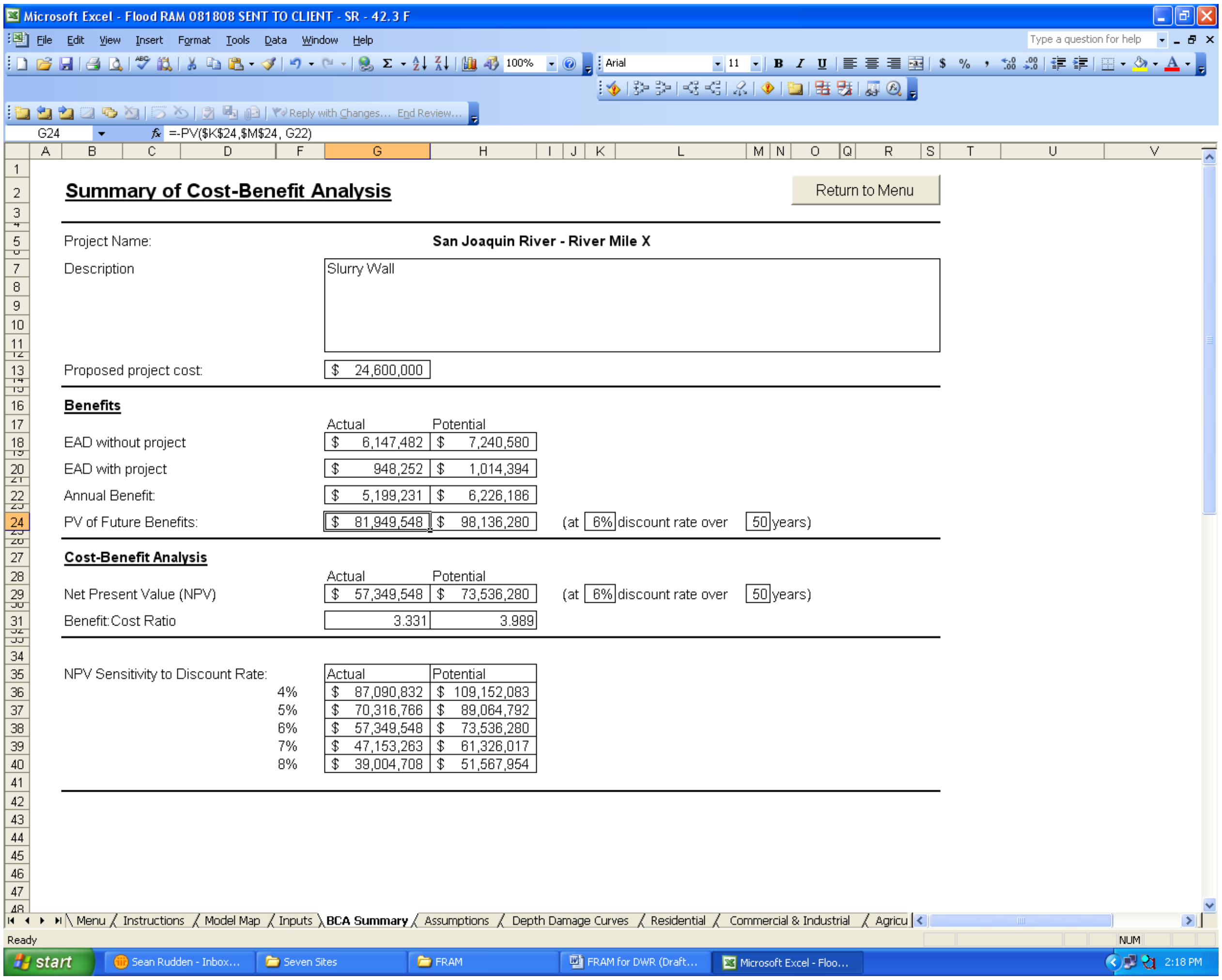
- Project name
- Project description
- Total proposed project cost

The remaining results are display two separate categories, actual damages and potential damages.

- Annual benefit (net) of undertaking the project (EAD with-project minus EAD without-project)
- Present value (PV) of future benefits
- Net present value (NPV) of the project
- Benefit: cost ratio (BCR) of the project
- The sensitivity of the NPV calculation to the discount rate being used.

Printing this worksheet provides a hard-copy summary of the project appraisal undertaken.

Figure A-3: F-RAM - BCA Summary Page

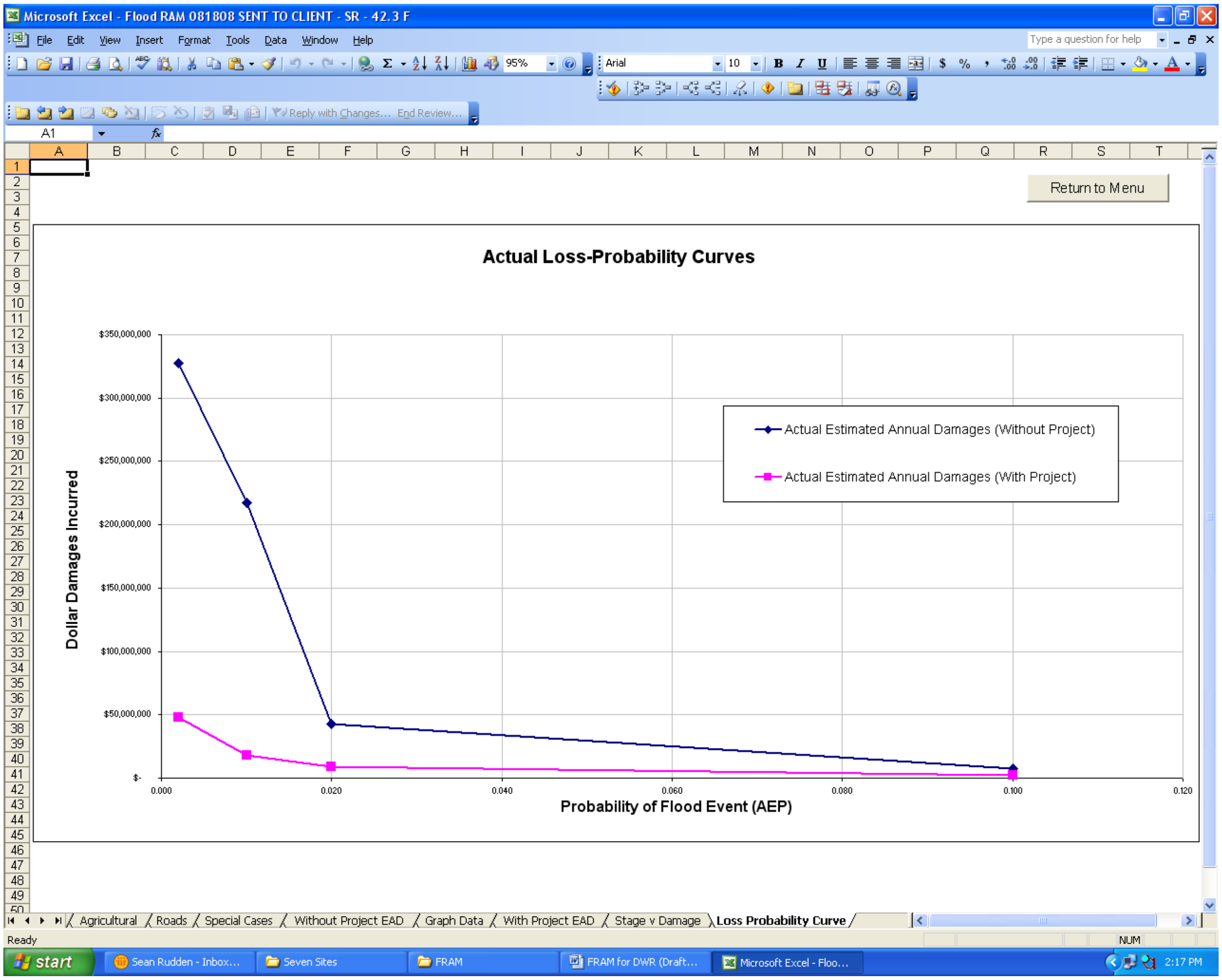


VIEWING LOSS-PROBABILITY ESTIMATED ANNUAL DAMAGE GRAPH

To view the actual stage damage curve, click on the "Stage v Damage Curve" button from the "Menu" worksheet. To view the actual EAD graph, click on the "Loss Probability Curve" button from the "Menu" worksheet.

The Loss-Probability Curves generated based on the data entered can be accessed from the Menu page. The graph is shown in Figure A-4. On this graph, the dark blue line represents the without-project Loss-Probability Curve, the area under it representing the without-project EAD. Similarly, the pink line represents the with-project Loss-Probability Curve, the area under it representing the with-project EAD. The area between these two lines represents the benefit of the flood mitigation project undertaken. These curves can be valuable in visualizing the impact of various flood mitigation measures.

Figure A-4: F-RAM – Viewing Actual Loss-Probability Curves



EDITING ASSUMPTIONS

***** WARNING: The assumptions underpinning the damage estimation methodology were made following extensive research. Assumptions should only be modified by an economist taking into consideration issues such as double-counting and economic loss. If these assumptions are modified, all previous project appraisals should be repeated so that investment prioritization is undertaken on a consistent basis. *****

It is possible to change the assumptions that underpin the damage estimation methodology, which are maintained in a single location on the “Assumptions” page. Changing one or more of the values on this page will automatically change the results of the file currently in use.

We believe it would only be prudent to change any of these assumptions if new information became available that improved on the data that was available during development of the flood damage estimation methodology.

Appendix B

Agricultural Damage Estimates

INTRODUCTION

Agricultural damage estimates were updated to reflect changes in both prices paid and prices received by farmers since the data was first used. This appendix describes the process used to update the estimates.

BACKGROUND

The estimates for agricultural damage due to flooding are from spreadsheets put together by the US Army Corp of Engineers, Sacramento District. The estimates of agricultural damages include: cultural costs (growing costs), harvest costs, establishment costs, land clean-up and rehabilitation costs, and lost income. All cost and income data is provided monthly.

> Cultural costs originated from the UC Davis Department of Agricultural and Resource Economics. These typically include costs such as subsoil treatment, irrigation, weed control, pest control and fertilization, as well as other costs that are more crop-specific.
>
> Harvest / post-harvest costs originated from the UC Davis Department of Agricultural and Resource Economics. These include costs related to the harvest, and typically include costs such as cutting, hauling and packing.
>
> Establishment costs originated from the UC Davis Department of Agriculture and Resource Economics. These are costs necessary to completely re-establish a crop that has been severely damaged and must begin all over from re-planting/seeding of the crops. This is usually for crops that need to be mature to be harvested, such as orchard crops. Establishment costs typically include costs such as: land preparation, planting, trees, production expenses and cash overhead for growing the crops up to the first year of viable harvest.

In producing agricultural damages associated with flooding, the costs associated with flooding were assessed for each month, and then the likelihood of flooding in each month was used to calculate the average annual damage estimate[7]. The damage estimates for agriculture, per acre, that were previously included in the F-RAM were from various years, but indexed to 1999. The purpose of this task was therefore to update those values to present day dollars.

METHODOLOGY

There were three steps to make the necessary changes to the model: (1) indices suitable for updating agricultural prices received and prices paid were assembled and analyzed; (2) prices paid and prices received from the agricultural budgets were matched with

[7] Information from this section comes from conversations with Steve Cowdin from the DWR (on April 28, 2008) and Gary Bedker from the USACE (on April 29, 2008) and the information subsequently found on the UC Davis website.

available indices; and, (3) the indices were used to update the agricultural damage estimates.

Step 1: Assemble indices to use to adjust agricultural prices for inflation

A price index is simply an indication of how prices have changed over time. The most well known price index is the Consumer Price Index (CPI). However, more appropriate (agriculture-specific) indices are produced by the U.S. Department of Agriculture (USDA).[8] The latest the data was available for is 2006 (from a 2007 report). Thus the updated estimates are in 2006 US dollars.

The raw data from this site was transformed in the following ways:

- To correct for any cyclical highs or lows, a 5-year rolling (i.e. moving) average was calculated for the indices for the 2002-2006 year period, so that when changes from the base year to 2006 were made, the data wasn't skewed to reflect peaks or troughs in the 2006 year.
    - For example the average of the index numbers from 2002-2006 for Cotton is 76 (a number of less than 100 indicates a decrease in cotton prices from the base years, 1990-1992; a number greater than 100 indicates an increase in prices).
- The data year index numbers were kept because if data was taken for a single year, it might be skewed, and taking an average over 5 years would not have corrected the original skewed number.
    - For example the index number from 1999 for Cotton is 85 (this indicates a decrease in prices from the base years, 1990-1992, and because it is higher than 76, the average of the index from 2002-2006 it means that prices continues to decrease).
- The "Prices Paid Index" and "Prices Received Index" multipliers were then created using the following equation:

$$\text{multiplier} = \frac{(\text{Rolling Average Price Index}_{2002\text{-}2006})}{(\text{Price Index}_{\text{base year}})}$$

    - For example, for Cotton, the multiplier = 76 / 85 = 0.894

Step 2: Match income and production costs in agricultural budgets with appropriate indices

The USDA indices for agriculture for prices paid are broken down into category of input. The composite category "Production Items, Interest, Taxes & Wage Rates" is used to adjust the estimates for (1) variable cost not expended, (2) establishment cost; and, (3) land clean-up & rehabilitation cost.

[8] These can be found in two places on the National Agricultural Statistics Service (NASS), Agricultural Statistics Board website at: http://usda.mannlib.cornell.edu/usda/nass/AgriPricSu//2000s/2000/AgriPricSu-07-24-2000.txt (for indices from 1991-1999) and http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1003 (for indices from 2000-2006) "Agricultural Prices 2006 Summary" July 20, 2007

To adjust the estimates for gross income, we used the USDA indices for agriculture for prices received. They are divided into the following categories:

- All Farm Products
- All Crops
- Food Grains
- Feed Grains & Hay
- Cotton
- Oil-Bearing Crops
- Fruit & Nuts
- Commercial Vegetables
- Potatoes & Dry Beans
- Other Crops
- Food Commodities

The categories do not correspond to the crops used in the agricultural crop budgets; however, we categorized product types into the most appropriate USDA category (Table B-1).

Table B-1: Crop product categories, data years, USDA categories and multipliers.

PRODUCT	Year	USDA category	Price Received Multiplier	Price Paid Multiplier
Corn	1999	Feed Grains & Hay	1.2047	1.1805
Rice	1998	Food Grain	1.1223	1.1702
Walnuts	1998	Fruit & Nuts	1.1207	1.1702
Almonds	1998	Fruit & Nuts	1.1207	1.1702
Cotton	1999	Cotton	0.8941	1.1805
Tomatoes	1997	Commercial Vegetables	1.1305	1.1305
Wine Grapes	1997	Fruit & Nuts	1.1413	1.1305
Alfalfa	1998	Feed Grains & Hay	1.0360	1.1702
Pasture	1993	Feed Grains & Hay	1.0465	1.3078
Safflower	1996	Oil-Bearing Crops	0.8359	1.1600
Sugar Beets	1994	Feed Grains & Hay	0.9774	1.2585
Beans	1999	Potatoes & Dry Beans	1.1420	1.1805

For example, to adjust for inflation the prices received for alfalfa, the original income is multiplied by 1.036. To adjust the prices paid for alfalfa, the original monthly cost estimates are multiplied by 1.1702.

Step 3: Integrate indices into the model to update costs and income estimates

The indices were integrated into the model by applying the multipliers to input prices and income. Also, the price adjustments were made to land clean-up and rehabilitation costs and re-establishment costs.

The data is aggregated into a weighted average annual damage estimate, based on income, variable costs not expended, probability of flood in that month and percent of damages that would occur if there was a flood. Land clean-up and rehabilitation costs are added as a fixed cost to each estimate, which are assumed to be the same for all crops. As well, if flood duration is longer than 5 days (or 3 days for alfalfa), a crop-specific establishment cost is added, which takes into account the cost of re-establishing permanent crops (e.g. orchards) that are increasingly damaged as flood duration increases. The estimates used are shown in Table B-2.

Table B-2: Crop product categories and cost estimates (per acre).

PRODUCT	Weighted Ave Annual Damages	Establishment Costs	Land Cleanup & Rehab	Total (<5d)	Total (>5d)	% Change <5d
Corn	$48	$0	$246	$293	$293	20%
Rice	$227	$0	$243	$471	$471	27%
Walnuts	$585	$5,284	$243	$828	$6,112	9%
Almonds	$1,618	$3,514	$243	$1,862	$5,376	12%
Cotton	$301	$0	$246	$547	$547	-14%
Tomatoes	$1,015	$0	$235	$1,250	$1,250	13%
Wine Grapes	$3,241	$3,240	$235	$3,476	$6,716	16%
Alfalfa	$250	$246	$243	$493	$739	-2%
Pasture	($15)	$82	$272	$257	$339	25%
Safflower	$164	$0	$241	$405	$405	-6%
Sugar Beets	$313	$0	$262	$575	$575	-6%
Beans	$111	$0	$246	$356	$356	14%
Other			$246	$246	$246	

For more information on these changes see the tables attached at the end of this Appendix.

NOTES ON THE AGRICULTURAL BUDGETS

The budgets contain information on monthly input costs, income, probability of failure by month and percent of damages that would be incurred, and land clean-up and rehabilitation costs.

Gross income estimates are, where available, derived from the County Commissioner's Report and are adjusted to reflect 3-5 year average prices.

Probability of failure / month was done by the USACE hydrologists, who took historical data, found in which month the peak water flow happened in each year, then took the number of observations for each month during that period and divided it by the number of observations over the length of the data set.

% Damages was calculated by the USACE and refers to how much damage happens to a crop if a flooding event occurs on the land where the crop is grown.

Land clean-up & rehab cost estimates were calculated by the USACE and reflect the type of land preparation and clean up activities that are required to restore land to its state before flooding.

Further documentation for the UC Davis data is available in the archived documents for each agricultural product on the UC Davis department of Agricultural and Resource Economics website, which can be found at: http://coststudies.ucdavis.edu/archived.php. Current data may be found at: http://coststudies.ucdavis.edu/current.php.

The updated budget spreadsheets for all of the crops used are attached. The indexed values are shaded blue.

1. CORN (Corn Silage - 2006 San Joaquin Valley)

Monthly Cash Costs Per Acre to Produce Crops

	Growing Season												
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total
Cultural Costs	$1	$1	$1	$1	$1	$1	$42	$121	$40	$72	$34	$13	**$328**
Harvest / Postharvest Costs	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$159	**$159**
Accumulated Variable Costs	$1	$2	$3	$4	$5	$6	$48	$169	$209	$281	$315	$487	**$487**
Variable Costs not expended	$486	$485	$484	$483	$482	$481	$439	$318	$278	$206	$172	$0	
Variable Costs not expended Update 1999 >1999 * (X 1.000) =	$486	$485	$484	$483	$482	$481	$439	$318	$278	$206	$172	$0	
Variable Costs not exp (indexed)	$574	$573	$571	$570	$569	$568	$518	$375	$328	$243	$203	$0	
Gross income	$0	$0	$0	$0	$0	$0	$0	$0	$521	$0	$0	$0	**$521**
Gross income (indexed)	$0	$0	$0	$0	$0	$0	$0	$0	$628	$0	$0	$0	**$628**
(Gross) - (Variable Costs not expended)	$35	$36	$37	$38	$39	$40	$82	$203	$243	$315	$349	$521	
gross-variable not exp (indexed)	$53	$55	$56	$57	$59	$60	$109	$252	$299	$384	$425	$628	
Probability of Failure by Month	0.058	0.124	0.177	0.200	0.170	0.132	0.082	0.030	0.010	0.002	0.002	0.013	**1.000**
% Damages	0	0	0	0.5	0.5	1	1	1	1	1	1	1	
Probability Damage by Month	$0.00	$0.00	$0.00	$3.80	$3.32	$5.28	$6.72	$6.09	$2.43	$0.63	$0.70	$6.77	**$35.74**
prob damage by month (indexed)	$0.00	$0.00	$0.00	$5.74	$4.98	$7.89	$8.97	$7.57	$2.99	$0.77	$0.85	$8.16	**$47.92**

Weighted Average Damage by Year	**$36**	**$48**
Land Clean Up and Rehab	**$208**	**$246**
Total Loss Per Failure	**$244**	**$293**
% increase		20%

* price paid for production =	1.000
PRICES PAID MULTIPLIER	1.1805
PRICES RECEIVED MULTIPLIER	1.2047

2. RICE (Rice - 2006 Sacramento Valley)

Monthly Cash Costs Per Acre to Produce Crops

	Growing Season												
	NOV	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**Total**
Cultural Costs (1998 PRICES)	$1	$1	$1	$3	$1	$125	$132	$17	$15	$12	$12	$1	**$321**
Harvest / Postharvest Costs	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$45	$109	**$154**
Accumulated Variable Costs	$1	$2	$3	$6	$7	$132	$264	$281	$296	$308	$365	$475	**$475**
Variable Costs not expended	$474	$473	$472	$469	$468	$343	$211	$194	$179	$167	$110	$0	
Variable Costs not expended Update 1999 >1999 * (X 1.000) =	$474	$473	$472	$469	$468	$343	$211	$194	$179	$167	$110	$0	
Variable Costs not exp (indexed)	$555	$553	$552	$549	$548	$401	$247	$227	$209	$195	$129	$0	
Gross income	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$800	**$800**
Gross income (indexed)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$898	**$898**
(Gross) - (Variable Costs not expended)	$326	$327	$328	$331	$332	$457	$589	$606	$621	$633	$690		
gross-variable not exp (indexed)	$343	$344	$346	$349	$350	$496	$651	$671	$688	$702	$769	$898	
Probability of Failure by Month	0.124	0.177	0.200	0.170	0.132	0.082	0.030	0.010	0.002	0.002	0.013	0.058	**1**
% Damages	1	0	0	0.5	0.5	1	1	1	1	1	1	1	
Probability Damage by Month	$40.42	$0.00	$0.00	$28.14	$21.91	$37.47	$17.67	$6.06	$1.24	$1.27	$8.97	$0.00	**$163.15**
prob damage by month (indexed)	$42.56	$0.00	$0.00	$29.67	$23.11	$40.71	$19.53	$6.71	$1.38	$1.40	$10.00	$52.08	**$227.15**

Weighted Average Damage by Year	**$163**	$227.15
Land Clean Up and Rehab	**$208**	$243.40
Total Loss Per Failure	**$371**	**$471**
% INCREASE		27%

* price paid for production =	1.000
PRICES PAID MULTIPLIER	1.1702
PRICES RECEIVED MULTIPLIER	1.1223

3. WALNUTS (2006 - Southern San Joaquin Valley)

Monthly Cash Costs Per Acre to Produce Crops

			Growing Season									
	OCT	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**
Cultural Costs (1998 PRICES)	$9	$18	$9	$66	$9	$9	$172	$81	$211	$61	$90	$31
Harvest / Postharvest Costs	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$511
Accumulated Variable Costs	$9	$27	$36	$102	$111	$120	$292	$373	$584	$645	$735	$1,277
Variable Costs not expended	$1,268	$1,250	$1,241	$1,175	$1,166	$1,157	$985	$904	$693	$632	$542	$0
Variable Costs not expended Update 1999 >1999 * (X 1.000) =	$1,268	$1,250	$1,241	$1,175	$1,166	$1,157	$985	$904	$693	$632	$542	$0
Variable Costs not expended (indexed)	$1,484	$1,463	$1,452	$1,375	$1,364	$1,354	$1,153	$1,058	$811	$740	$634	$0
Gross income	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1,724
Gross income (indexed)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1,932
(Gross) - (Variable Costs not expended)	$456	$474	$483	$549	$558	$567	$739	$820	$1,031	$1,092	$1,182	
Gross Margin not expended (indexed)	$448	$469	$480	$557	$568	$578	$779	$874	$1,121	$1,193	$1,298	$1,932
Probability of Failure by Month	0.058	0.124	0.177	0.200	0.170	0.132	0.082	0.030	0.010	0.002	0.002	0.013
% Damages	1	1	1	1	1	1	1	1	1	1	1	1
Probability Damage by Month	$26.45	$58.78	$85.49	$109.80	$94.86	$74.84	$60.60	$24.60	$10.31	$2.18	$2.36	$0.00
Probability Damage by Month (indexed)	$26.00	$58.21	$84.95	$111.43	$96.51	$76.33	$63.92	$26.23	$11.21	$2.39	$2.60	$25.12
	>=5d	**>=5d**	**<5d**	**<5d**								
Weighted Average Damage by Year	**$550**	$584.88	**$550**	$584.88								
1/2 Establishment Costs of $9,031 * PRICE FACTOR	**$4,516**	$5,283.93	**$0**	**$0**								
Land Clean Up and Rehab	**$208**	$243.40	**$208**	$243.40								
Total Loss Per Failure	**$5,274**	**$6,112**	**$758**	**$828**								
% increase		16%		9%								

* price paid for production =	1.000
PRICES PAID MULTIPLIER	1.1702
PRICES RECEIVED MULTIPLIER	1.1207

4. ALMONDS (2006 - Northern San Joaquin Valley)

Monthly Cash Costs Per Acre to Produce Crops

Growing Season

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
Cultural Costs (1998 PRICES)	$0	$0	$247	$111	$257	$36	$129	$42	$56	$136	$47
Harvest / Postharvest Costs	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Accumulated Variable Costs	$0	$0	$247	$358	$615	$651	$780	$822	$878	$1,014	$1,061
Variable Costs not expended	$1,421	$1,421	$1,174	$1,063	$806	$770	$641	$599	$543	$407	$360
Variable Costs not expended Update 1999 >1999 * (X 1.000) =	$1,421	$1,421	$1,174	$1,063	$806	$770	$641	$599	$543	$407	$360
Variable Costs not expended (indexed)	$1,663	$1,663	$1,374	$1,244	$943	$901	$750	$701	$635	$476	$421
Gross income	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Gross income (indexed)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
(Gross) - (Variable Costs not expended)	$1,062	$1,062	$1,309	$1,420	$1,677	$1,713	$1,842	$1,884	$1,940	$2,076	$2,123
Gross Margin not expended (indexed)	$1,120	$1,120	$1,409	$1,539	$1,840	$1,882	$2,033	$2,082	$2,147	$2,306	$2,361
Probability of Failure by Month	0.058	0.124	0.177	0.200	0.170	0.132	0.082	0.030	0.010	0.002	0.002
% Damages	1	1	1	1	1	1	1	1	1	1	1
Probability Damage by Month	$61.60	$131.69	$231.69	$284.00	$285.09	$226.12	$151.04	$56.52	$19.40	$4.15	$4.25
Probability Damage by Month (indexed)	$64.96	$138.87	$249.39	$307.77	$312.73	$248.39	$166.68	$62.45	$21.47	$4.61	$4.72

	>=5d	>=5d	<5d	<5d
Weighted Average Damage by Year	**$1,456**	**$1,618**	**$1,456**	**$1,618**
1/2 Establishment Costs of $6,006 * PRICE FACTOR	**$3,003**	$3,514	**$0**	$0
Land Clean Up and Rehab	**$208**	$243	**$208**	$243
Total Loss Per Failure	**$4,667**	**$5,376**	**$1,664**	**$1,862**
% INCREASE		15.2%		11.9%

* price paid for production =	1.000
PRICES PAID MULTIPLIER	1.1702
PRICES RECEIVED MULTIPLIER	1.1207

5. COTTON (2006 - Cotton Pima Varieties San Joaquin Valley)

Monthly Cash Costs Per Acre to Produce Crops

	Growing Season												
	DEC	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**Total**
Cultural Costs	$1	$1	$44	$4	$34	$29	$117	$176	$48	$2	$72	$45	**$573**
Harvest / Postharvest Costs	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$86	**$86**
Accumulated Variable Costs	$1	$2	$46	$50	$84	$113	$230	$406	$454	$456	$528	$659	**$659**
Variable Costs not expended	$658	$657	$613	$609	$575	$546	$429	$253	$205	$203	$131	$0	
Variable Costs not expended Update 1999 >1999 * (X 1.000) =	$658	$657	$613	$609	$575	$546	$429	$253	$205	$203	$131	$0	
Variable Costs not expended (indexed)	$777	$776	$724	$719	$679	$645	$506	$299	$242	$240	$155	$0	
Gross income	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1,102	**$1,102**
Gross income (indexed)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$985	**$985**
(Gross) - (Variable Costs not expended)	$444	$445	$489	$493	$527	$556	$673	$849	$897	$899	$971	$1,102	
Gross Margin not expended (indexed)	$208	$210	$262	$266	$307	$341	$479	$687	$743	$746	$831	$985	
Probability of Failure by Month	0.177	0.200	0.170	0.132	0.082	0.030	0.010	0.002	0.002	0.013	0.058	0.124	**1.000**
% Damages	0	0.5	0.5	1	1	1	1	1	1	1	1	1	
Probability Damage by Month	$0.00	$44.50	$41.57	$65.08	$43.21	$16.68	$6.73	$1.70	$1.79	$11.69	$56.32	$136.65	**$425.91**
Probability Damage by Month (indexed)	$0.00	$20.97	$22.24	$35.16	$25.13	$10.22	$4.79	$1.37	$1.49	$9.69	$48.18	$122.18	

Weighted Average Damage by Year	**$426**	**$301**
Land Clean Up and Rehab	**$208**	$245.55
Total Loss Per Failure	**$634**	**$547**
% INCREASE		-13.71%

* price paid for production =	1.000
PRICES PAID MULTIPLIER	1.1805
PRICES RECEIVED MULTIPLIER	0.8941

6. TOMATOES (2006 - Processing Tomatoes Yolo County)

Monthly Cash Costs Per Acre to Produce Crops

Growing Season	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total
Cultural Costs (1997 PRICES)	$36	$0	$0	$19	$12	$233	$140	$203	$41	$100	$43	$50	**$877**
Harvest / Postharvest Costs	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$215	**$215**
Accumulated Variable Costs	$36	$36	$36	$55	$67	$300	$440	$643	$684	$784	$827	$1,092	**$1,092**
Variable Costs not expended	$1,056	$1,056	$1,056	$1,037	$1,025	$792	$652	$449	$408	$308	$265	$0	
Variable Costs not expended Update 1999 >1999 * (X 1.000) =	$1,056	$1,056	$1,056	$1,037	$1,025	$792	$652	$449	$408	$308	$265	$0	
Variable Costs not expended (indexed)	$1,194	$1,194	$1,194	$1,172	$1,159	$895	$737	$508	$461	$348	$300	$0	
Gross income	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1,837	**$1,837**
Gross income (indexed)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$2,077	**$2,077**
(Gross) - (Variable Costs not expended)	$781	$781	$781	$800	$812	$1,045	$1,185	$1,388	$1,429	$1,529	$1,572	$1,837	
Gross Margin not expended (indexed)	$883	$883	$883	$904	$918	$1,181	$1,340	$1,569	$1,615	$1,729	$1,777	$2,077	
Probability of Failure by Month	0.002	0.013	0.058	0.124	0.177	0.200	0.170	0.132	0.082	0.030	0.010	0.002	**1**
% Damages	0	0	0	0.5	0.5	1	1	1	1	1	1	1	
Probability Damage by Month	$0.00	$0.00	$0.00	$49.60	$71.86	$209.00	$201.45	$183.22	$117.18	$45.87	$15.72	$3.67	**$898**
Probability Damage by Month (indexed)	$0.00	$0.00	$0.00	$56.07	$81.24	$236.28	$227.74	$207.13	$132.47	$51.86	$17.77	$4.15	**$1,015**

Weighted Average Damage by Year	**$898**	$1,014.71
Land Clean Up and Rehab	**$208**	$235.15
Total Loss Per Failure	**$1,106**	**$1,250**
% INCREASE		13.05%

* price paid for production =	1.000
PRICES PAID MULTIPLIER	1.1305
PRICES RECEIVED MULTIPLIER	1.1305

7. WINE GRAPES (2006 - San Joaquin Valley)

Monthly Cash Costs Per Acre to Produce Crops

	Growing Season										
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
Cultural Costs (1997 PRICES)	$7	$7	$7	$137	$7	$97	$90	$60	$157	$53	$30
Harvest / Postharvest Costs	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Accumulated Variable Costs	$7	$14	$21	$158	$165	$262	$352	$412	$569	$622	$652
Variable Costs not expended	$1,125	$1,118	$1,111	$974	$967	$870	$780	$720	$563	$510	$480
Variable Costs not expended Update 1999 >1999 * (X 1.000) =	$1,125	$1,118	$1,111	$974	$967	$870	$780	$720	$563	$510	$480
Variable Costs not expended (indexed)	$1,272	$1,264	$1,256	$1,101	$1,093	$984	$882	$814	$636	$577	$543
Gross income	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Gross income (indexed)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
(Gross) - (Variable Costs not expended)	$2,673	$2,680	$2,687	$2,824	$2,831	$2,928	$3,018	$3,078	$3,235	$3,288	$3,318
Gross Margin not expended (indexed)	$3,063	$3,071	$3,079	$3,233	$3,241	$3,351	$3,453	$3,521	$3,698	$3,758	$3,792
Probability of Failure by Month	0.058	0.124	0.177	0.200	0.170	0.132	0.082	0.030	0.010	0.002	0.002
% Damages	1	1	1	1	1	1	1	1	1	1	1
Probability Damage by Month	$155.03	$332.32	$475.60	$564.80	$481.27	$386.50	$247.48	$92.34	$32.35	$6.58	$6.64
Probability Damage by Month (indexed)	$177.64	$380.77	$544.91	$646.70	$551.04	$442.34	$283.13	$105.62	$36.98	$7.52	$7.58

	>=5d	>=5d	<5d	<5d
Weighted Average Damage by Year	**$2,781**	$3,240.57	**$2,781**	$3,240.57
1/2 Establishment Costs of $5,732 * PRICE FACTOR	**$2,866**	$3,240.04	**$0**	$0.00
Land Clean Up and Rehab	**$208**	$235.15	**$208**	$235.15
Total Loss Per Failure	**$5,855**	**$6,716**	**$2,989**	**$3,476**
% INCREASE		14.70%		16.29%

* price paid for production =	1.000
PRICES PAID MULTIPLIER	1.1305
PRICES RECEIVED MULTIPLIER	1.1413

8. ALFALFA (2006 - Alfalfa Hay Sacramento Valley)

Monthly Cash Costs Per Acre to Produce Crops

	Growing Season												
	OCT	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**Total**
Cultural Costs (1998 PRICES)	$0	$0	$0	$62	$1	$49	$23	$22	$28	$82	$58	$22	**$347**
Harvest / Postharvest Costs	$0	$0	$0	$0	$0	$0	$31	$31	$31	$31	$62	$31	**$217**
Accumulated Variable Costs	$0	$0	$0	$62	$63	$112	$166	$219	$278	$391	$511	$564	**$564**
Variable Costs not expended	$564	$564	$564	$502	$501	$452	$398	$345	$286	$173	$53	$0	
Variable Costs not expended Update 1999 >1999 * (X 1.000) =	$564	$564	$564	$502	$501	$452	$398	$345	$286	$173	$53	$0	
Variable Costs not expended (indexed)	$660	$660	$660	$587	$586	$529	$466	$404	$335	$202	$62	$0	
Gross income	$0	$0	$0	$0	$0	$0	$133	$133	$133	$133	$133	$133	**$799**
Gross income (indexed)	$0	$0	$0	$0	$0	$0	$138	$138	$138	$138	$138	$138	**$828**
(Gross) - (Variable Costs not expended)	$235	$235	$235	$297	$298	$347	$401	$454	$513	$626	$746		
Gross Margin not expended (indexed)	$168	$168	$168	$240	$242	$299	$362	$424	$493	$625	$766	$828	
Probability of Failure by Month	0.058	0.124	0.177	0.200	0.170	0.132	0.082	0.030	0.010	0.002	0.002	0.013	**1**
% Damages	1	1	1	1	1	1	1	1	1	1	1	1	
Probability Damage by Month	$13.63	$29.14	$41.60	$59.40	$50.66	$45.81	$32.88	$13.62	$5.13	$1.25	$1.49	$0.00	**$294.62**
Probability Damage by Month (indexed)	$9.73	$20.81	$29.70	$48.07	$41.06	$39.45	$29.69	$12.72	$4.93	$1.25	$1.53	$10.76	**$249.71**

	>3d	>3d	<=3d	<=3d
Weighted Average Damage by Year	**$295**	**$250**	**$295**	$249.71
1/2 Establishment Costs of $421 * PRICE FACTOR	**$211**	$246.32	**$0**	$0.00
Land Clean Up and Rehab	**$208**	$243.40	**$208**	$243.40
Total Loss Per Failure	**$713**	**$739**	**$503**	**$493**
% INCREASE		3.69%		-1.89%

* price paid for production =	1.000
PRICES PAID MULTIPLIER	1.1702
PRICES RECEIVED MULTIPLIER	1.0360

9. PASTURE (2006 - Stanislaus and San Joaquin Counties)

Monthly Cash Costs Per Acre to Produce Crops

	Growing Season											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Cultural Costs	$12	$12	$12	$12	$12	$12	$12	$12	$12	$12	$12	$12
Harvest / Postharvest Costs	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Accumulated Variable Costs	$12	$24	$36	$48	$60	$72	$84	$96	$107	$119	$131	$143
Variable Costs not expended	$131	$119	$107	$96	$84	$72	$60	$48	$36	$24	$12	$0
Variable Costs not expended Update 1999 >1999 * (X 1.125) =	$148	$134	$121	$107	$94	$81	$67	$54	$40	$27	$13	$0
Variable Costs not expended (indexed)	$172	$156	$141	$125	$109	$94	$78	$62	$47	$31	$16	$0
Gross income	$8	$8	$8	$8	$8	$8	$8	$8	$8	$8	$8	$8
Gross income (indexed)	$9	$9	$9	$9	$9	$9	$9	$9	$9	$9	$9	$9
(Gross) - (Variable Costs not expended)	($49)	($35)	($22)	($8)	$5	$18	$32	$45	$59	$72	$86	$99
Gross Margin not expended (indexed)	($68)	($53)	($37)	($21)	($6)	$10	$26	$41	$57	$72	$88	$104
Probability of Failure by Month	0.058	0.124	0.177	0.200	0.170	0.132	0.082	0.030	0.010	0.002	0.002	0.013
% Damages	1	1	1	1	1	1	1	1	1	1	1	1
Probability Damage by Month	($2.83)	($4.38)	($3.87)	($1.69)	$0.85	$2.43	$2.61	$1.36	$0.59	$0.14	$0.17	$1.29
Probability Damage by Month (indexed)	($3.95)	($6.52)	($6.54)	($4.27)	($0.97)	$1.31	$2.09	$1.23	$0.57	$0.14	$0.18	$1.35

	>=5d	>=5d	<5d	<5d
Weighted Average Damage by Year	**($3)**	**($15)**	**($3)**	**($15)**
1/2 Establishment Costs of $111.60 * PRICE FACTOR	**$63**	$82.10	**$0**	$0.00
Land Clean Up and Rehab	**$208**	$272.03	**$208**	$272.03
Total Loss Per Failure	**$267**	**$339**	**$205**	**$257**
% INCREASE		26.67%		25.41%

* price paid for production =	1.125
PRICES PAID MULTIPLIER	1.3078
PRICES RECEIVED MULTIPLIER	1.0465

10. SAFFLOWER (Safflower - 2006 Irrigated In Yolo County)

Monthly Cash Costs Per Acre to Produce Crops

	Growing Season												
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total
Cultural Costs	$4	$0	$0	$0	$0	$55	$19	$30	$0	$1	$0	$0	**$109**
Harvest / Postharvest Costs	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$17	**$17**
Accumulated Variable Costs	$4	$4	$4	$4	$4	$59	$78	$108	$108	$109	$109	$126	**$126**
Variable Costs not expended	$122	$122	$122	$122	$122	$67	$48	$18	$18	$17	$17	$0	
Variable Costs not expended Update 1999 >1999 * (X 1.017) =	$124	$124	$124	$124	$124	$68	$49	$18	$18	$17	$17	$0	
Variable Costs not expended (indexed)	$142	$142	$142	$142	$142	$78	$56	$21	$21	$20	$20	$0	
Gross income	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$383	**$383**
Gross income (indexed)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$320	**$320**
(Gross) - (Variable Costs not expended)	$259	$259	$259	$259	$259	$315	$334	$365	$365	$366	$366	$383	
Gross Margin not expended (indexed)	$179	$179	$179	$179	$179	$242	$264	$299	$299	$300	$300	$320	
Probability of Failure by Month	0.058	0.124	0.177	0.200	0.170	0.132	0.082	0.030	0.010	0.002	0.002	0.013	**1.000**
% Damages	0	0.5	0.5	1	1	1	1	1	1	1	1	1	
Probability Damage by Month	$0.00	$16.05	$22.91	$51.79	$44.02	$41.56	$27.40	$10.94	$3.65	$0.73	$0.73	$4.98	**$224.77**
Probability Damage by Month (indexed)	$0.00	$11.08	$15.81	$35.73	$30.37	$32.00	$21.69	$8.98	$2.99	$0.60	$0.60	$4.16	**$164.01**

Weighted Average Damage by Year	**$225**	**$164**
Land Clean Up and Rehab	**$208**	$241.28
Total Loss Per Failure	**$433**	**$405**
% INCREASE		-6.35%
* price paid for production =	1.017	
PRICES PAID MULTIPLIER	1.1600	
PRICES RECEIVED MULTIPLIER	0.8359	

11. SUGAR BEETS (2006 Sugar Beets - Spring Planted and Fall Harvest in Yolo County)

Monthly Cash Costs Per Acre to Produce Crops

	Growing Season												
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total
Cultural Costs	$56	$0	$36	$55	$0	$301	$73	$26	$27	$48	$61	$87	$771
Harvest / Postharvest Costs	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$115	$115
Accumulated Variable Costs	$56	$57	$93	$147	$148	$449	$522	$548	$575	$623	$685	$886	$886
Variable Costs not expended	$830	$829	$793	$738	$738	$436	$364	$338	$311	$262	$201	$0	
Variable Costs not expended Update 1999 >1999 * (X 1.114) =	$924	$924	$884	$822	$822	$486	$405	$376	$346	$292	$224	$0	
Variable Costs not expended (indexed)	$1,044	$1,044	$998	$929	$928	$549	$457	$425	$391	$330	$253	$0	
Gross income	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1,212	$1,212
Gross income (indexed)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1,185	$1,185
(Gross) - (Variable Costs not expended)	$288	$288	$328	$390	$390	$726	$807	$836	$866	$920	$988	$1,212	
Gross Margin not expended (indexed)	$140	$141	$186	$256	$256	$635	$727	$760	$794	$855	$932	$1,185	
Probability of Failure by Month	0.058	0.124	0.177	0.200	0.170	0.132	0.082	0.030	0.010	0.002	0.002	0.013	1.000
% Damages	0	0.5	0.5	1	1	1	1	1	1	1	1	1	
Probability Damage by Month	$0.00	$17.87	$29.07	$77.92	$66.33	$95.83	$66.18	$25.08	$8.66	$1.84	$1.98	$15.76	$406.51
Probability Damage by Month (indexed)	$0.00	$8.74	$16.49	$51.10	$43.54	$83.88	$59.62	$22.79	$7.94	$1.71	$1.86	$15.40	$313.09

Weighted Average Damage by Year	$407	$313
Land Clean Up and Rehab	$208	$261.77
Total Loss Per Failure	$615	$575
% INCREASE		-6.45%

* price paid for production =	1.114
PRICES PAID MULTIPLIER	1.2585
PRICES RECEIVED MULTIPLIER	0.9774

12. BEANS (Beans Common Dry Varieties - 2006 Sacramento Valley)

Monthly Cash Costs Per Acre to Produce Crops

	Growing Season												
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total
Cultural Costs	$18	$2	$2	$2	$2	$2	$9	$2	$148	$68	$56	$3	**$314**
Harvest / Postharvest Costs	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$139	**$139**
Accumulated Variable Costs	$18	$20	$22	$24	$26	$28	$37	$39	$187	$255	$311	$453	**$453**
Variable Costs not expended	$435	$433	$431	$429	$427	$425	$416	$414	$266	$198	$142	$0	
Variable Costs not expended Update 1999 >1999 * (X 1.000) =	$435	$433	$431	$429	$427	$425	$416	$414	$266	$198	$142	$0	
Variable Costs not expended (indexed)	$514	$511	$509	$506	$504	$502	$491	$489	$314	$234	$168	$0	
Gross income	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$632	**$632**
Gross income (indexed)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$722	**$722**
(Gross) - (Variable Costs not expended)	$197	$199	$201	$203	$205	$207	$216	$218	$366	$434	$490	$632	
Gross Margin not expended (indexed)	$208	$211	$213	$215	$218	$220	$231	$233	$408	$488	$554	$722	
Probability of Failure by Month	0.058	0.124	0.177	0.200	0.170	0.132	0.082	0.030	0.010	0.002	0.002	0.013	**1.000**
% Damages	0	0	0	0.5	0.5	1	1	1	1	1	1	1	
Probability Damage by Month	$0.00	$0.00	$0.00	$20.30	$17.43	$27.32	$17.71	$6.54	$3.66	$0.87	$0.98	$8.22	**$103.03**
Probability Damage by Month (indexed)	$0.00	$0.00	$0.00	$21.53	$18.50	$29.04	$18.91	$6.99	$4.08	$0.98	$1.11	$9.38	**$110.52**

Weighted Average Damage by Year	**$103**	**$111**
Land Clean Up and Rehab	**$208**	$245.55
Total Loss Per Failure	**$311**	**$356**
% INCREASE		14.48%

* price paid for production =	1.000
PRICES PAID MULTIPLIER	1.1805
PRICES RECEIVED MULTIPLIER	1.1420

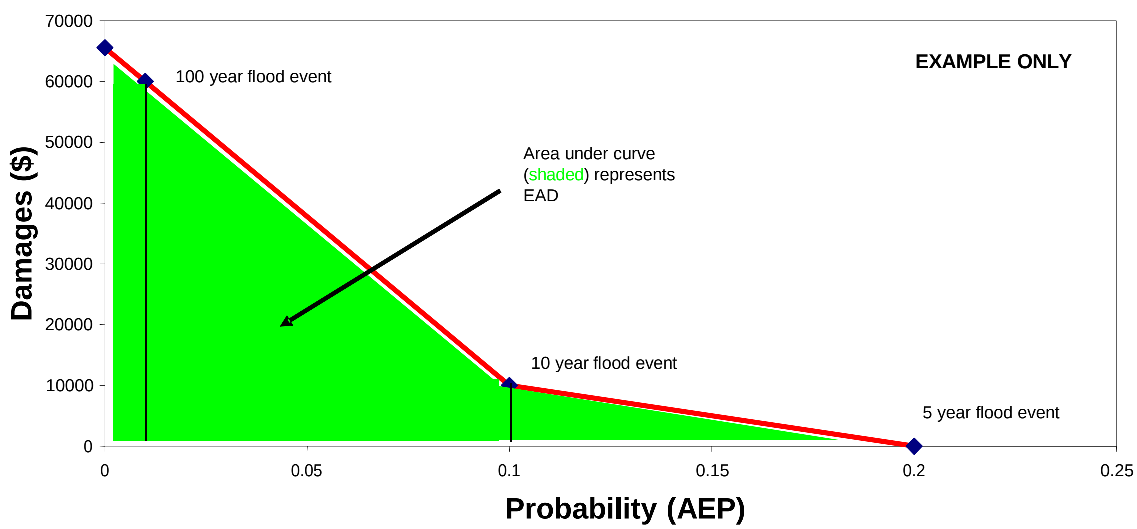
Appendix C

F-RAM Documented Assumptions

METHOD USED TO ASSESS DAMAGES

In estimating the cost of flood damages, a loss-probability curve, such as that shown on Figure C-1, is developed. The curve plots damages against their probability of exceedance. For example, the large damages resulting from a major flood event are plotted against a low probability (e.g., probability of 0.01 for a flood with an ARI of 100 years), and the relatively smaller damages from a minor flood are plotted against a higher probability (e.g., probability of 0.1 for a 10-year ARI event).

Figure C-1 Loss-Probability Curve and Expected Annual Damages



The area under the curve represents the average or EAD resulting from all flood events over a long period. This area can be estimated by integrating the loss-probability curve**.** The EAD is the average loss due to flooding that could be expected to occur in any given year.

Flood mitigation benefits can be calculated by estimating the change in EAD with and without various project alternatives.

DETAILED METHODOLOGY

Any assessment of flood damages is only as good as the data that is used to make the estimate. Wherever possible, the F-RAM uses available spatial datasets to quantify the number and size of different buildings, land uses and infrastructure assets inundated. The quality of these datasets ultimately determines the quality of the flood damage assessment made.

Within this Appendix, our approach and assumptions for estimating damages are presented and discussed.

Estimating Flood Damages Associated With Buildings

Several types of damage to buildings are discussed in this section:

- Damages to structures (residential, commercial and industrial)
- Damages to the contents of these buildings
- Damage to gardens
- Clean-up costs

Damages to buildings (structural and contents) are typically assessed from depth-damage curves. These curves define mean levels of damage per building for various depths of flooding, and for various classes of building (see Table C-1). Classifications include one- and two-story residential buildings, commercial buildings, industrial buildings, mobile homes, farm homesteads, and public buildings.

HEC-FIA

The Hydrologic Engineering Center – Flood Impact Analysis (HEC-FIA) model that is being developed by the United States Army Corps of Engineers (USACE) can be used to provide estimates for building and contents damages.

To operate this model, a skilled GIS technician is required. To produce flood damages, the GIS analyst must obtain hydraulic and hydrological data for a flood event (depth and extent), a digital elevation model (DEM), and 2000 census data on the number and type of buildings within each affected census block. HEC-FIA has been developed to communicate directly with HAZUS to extract census block data.

The depth damage functions within HEC-FIA are the same as those outlined in Table C-1.

Building Count and Averages

Damages to buildings (structural and contents) are assessed using:

- Depth-damage curves developed by the USACE for different building types
- Estimates of the mean depreciated value of different building types
- Estimates of the number and type of building inundated for different flood events (AEP)
- Data on the mean depth of inundation for each flood event

The F-RAM approach is to estimate the number of residential buildings and the area of commercial/industrial buildings inundated for each flood event. The number, type and size of buildings inundated are estimated using a combination of parcel data, aerial photography and site visits. Given the coarseness of the National Elevation Database (NED) dataset, the absence of floor height data, and the need for rapid analysis, the approach taken was to assess the mean depth of flooding for residential and commercial/industrial buildings within each flood extent. This assumption can be tested using sensitivity analysis.

Table C-1 Depth Damage Curves, Defining Damages as a Percentage of Depreciated Building Value for Depth of Flooding Above Floor Height

Occ_Name	Cat_Name	Occ_Description	Parameter	Depth (ft) above First Finished Floor (FFE)												
1ST-NB	RES	one story, no basement	Stage	-2	-1	0	1	2	3	4	5	6	7	8	9	10
1ST-NB	RES		S	0	2.5	13.4	23.3	32.1	40.1	47.1	53.2	58.6	63.2	67.2	70.5	73.2
1ST-NB	RES		C	0	2.4	8.1	13.3	17.9	22	25.7	28.8	31.5	33.8	35.7	37.2	38.4
2ST-NB	RES	two or more stories, no basement	Stage	-2	-1	0	1	2	3	4	5	6	7	8	9	10
2ST-NB	RES		S	0	3	9.3	15.2	20.9	26.3	31.4	36.2	40.7	44.9	48.8	52.4	55.7
2ST-NB	RES		C	0	1	5	8.7	12.2	15.5	18.5	21.3	23.9	26.3	28.4	30.3	32
FARM	FAR	Farm Homesteads	Stage	-10	-3	-2	-1	0	1	2	3	4	5	6	7	8
FARM	FAR		S	0	0	0	0	4	9	13	18	22	27	31	35	38
FARM	FAR		C	0	0	0	0	0	6	30	54	69	75	78	80	80
MOBILE	MOB	Mobile homes	Stage	-10	-3	-2	-1	0	1	2	3	4	5	6	7	8
MOBILE	MOB		S	0	0	0	0	8	44	63	73	78	80	81	82	82
MOBILE	MOB		C	0	0	0	0	0	27	49	64	70	76	78	79	81
PUBLIC	PUB	Public buildings	Stage	-10	-3	-2	-1	0	1	2	3	4	5	6	7	8
PUBLIC	PUB		S	0	0	0	0	8	22	30	35	39	41	44	46	48
PUBLIC	PUB		C	0	0	0	0	0	17.5	25	30	34	37	39	40.5	41.5
INDUSTRY	IND	Industrial Buildings	Stage	-10	-3	-2	-1	0	1	2	3	4	5	6	7	8
INDUSTRY	IND		S	0	0	0	0	4	9	13	18	22	27	31	35	38
INDUSTRY	IND		C	0	0	0	0	0	72	75	76.5	78	81	84	87	90
COMMERCIAL	COM	Commercial Buildings	Stage	-10	-3	-2	-1	0	1	2	3	4	5	6	7	8
COMMERCIAL	COM		S	0	0	0	0	4	9	13	18	22	27	31	35	38
COMMERCIAL	COM		C	0	0	0	0	0	11	30	54	69	75	78	80	80

Source:

USACE Generic Depth Damage Curves for residential buildings with basements (USACE 2003).

USACE depth damage curves for farm homesteads, mobile homes, public buildings, industrial buildings and commercial buildings, as used in the Comprehensive Study and documented in Ford (2005).

Note

The Comprehensive Study depth damage curves for contents were modified to reflect the estimated ratio of contents to structural values. These assumptions were taken from Ford (2005).

Depth refers to depth of flooding above floor level.

S = Structural, C = Contents.

Estimates for the depreciated value for different types of residential buildings, and estimates of low, medium, and high construction costs for commercial/industrial buildings were then combined with depth-damage curves for structural damage and contents damage to assess flood damages to buildings.

Assumptions: The assumptions for assessing damages to buildings are summarized in Table C-2 and Table C-3.

Table C-2 Foundation Heights

Structure Category	Foundation Height (ft)
Rural - Res: Homesteads	1.5
Rural - Other: Barns, sheds	0
Urban Res: Single story (no base)	1.1
Urban Res: Two plus story (no base)	1.1
Mobile home	2.0
Commercial: Low	1
Commercial: Medium	1
Commercial: High	1
Industrial: Low	0.5
Industrial: Medium	0.5
Industrial: High	0.5

ft = feet

Table C-3 Estimated Replacement Value

Structure Category	Unit Cost $/ft^2 (2)	Average Size ft^2 (1)	Construction Cost
Rural - Res: Homesteads	159	1900	302100
Rural - Other: Barns, sheds	98	4000	392000
Urban Res: Single story (no base)	159	1900	302100
Urban Res: Two plus story (no base)	155	2200	341000
Mobile home (3)	98	1180	115640
Commercial: Low	120		0
Commercial: Medium	142		0
Commercial: High	207		0
Industrial: Low	120		0
Industrial: Medium	142		0
Industrial: High	207		0

1. Residential Square Footage Source: Sacramento County Tax Assessor Unit Cost and Commercial/Industrial/Public Square Footage Assumptions Source: Saylor Publications, Inc, 2007 Current Construction Costs

2. Replacement unit cost per square foot reflects average costs in the San Francisco area.

3. According to FEMA guidance, replacement costs per square foot for mobile homes and barns and outbuildings are similar.

ft^2 = square feet

From a previous URS study (2006) we have defined external damages as the cost of flooding to gardens and other outdoor structures. Damages have been estimated at $5,000 per residential building.

From that same study it was found that clean-up costs are estimated at $4,000 per building for all residential homes, and at 30 percent of direct structural damages for commercial and industrial buildings.

Structural and content damages for buildings are calculated by multiplying the estimated *depreciated* value of buildings by the relevant stage damage curve. Depreciated value for buildings is estimated by multiplying the construction value (Table C-3) by a site-specific variable (percentage) that is varied, depending on the average age/condition of buildings within a flood extent.

Estimating Flood Damages Associated With Agriculture

Types of agricultural flood damage evaluated in this section include the loss of direct production costs incurred prior to flooding, the loss of net value (income) of crop, the loss of depreciated value of perennial crops, and land clean up and rehabilitation costs. In addition to flood depths, the effects of seasonality and flooding duration are considered in the calculation of agricultural flood damages for each crop. These two factors are often are more important than flood depths.

For analytical purposes, 12 crops were selected as being representative of all crops grown within the study area: corn, rice, walnuts, almonds, cotton, tomatoes, wine grapes, alfalfa, pasture, safflower, sugar beets and beans.

Approach: The following flood damages are associated with agriculture:

- **Loss of the cumulative production (variable) costs incurred prior to flooding**: Production costs are incurred periodically throughout the crop year and include field preparation, chemical and fertilizer application, hired labor, planting, weed and pest control, harvesting, etc. These costs are computed on a monthly basis to determine the cumulative amount of production costs that are expended (and thus lost).
- **Loss of the crop net income affected by the flood event**: Crop net income is determined by subtracting the direct production (variable) costs from gross income. Loss of crop net income is a significant part of agricultural damage.
- **Loss of perennial crop depreciated value as a direct result of flooding**: Damage caused by long-term duration flooding may result in permanent loss of perennial crops (for example, permanent reductions in crop yields). The damage to perennials susceptible to flooding is computed based upon the assumption that the crop stands are at various ages, ranging from year 1 throughout their economic useful life. Accordingly, damage caused by long-term duration flooding is computed based upon a stand that is at the mid-point of its economic useful life.
- **Cost of activities associated with land clean up and rehabilitation resulting from flooding**: Erosion and deposition of debris and sediment may be caused by floods of any duration or time of year. Additionally, drainage and irrigation ditches may

become clogged with silt and debris. Clean up and rehabilitation of farm acreage is accounted for in the computation of agricultural flood damages.

For the Comprehensive Study (USACE 2002), estimates of flooding losses were determined for a range of agricultural land uses within the Sacramento and San Joaquin River Basins. The Comprehensive Study estimated flood damages for different crops as a weighted average annual cost based on the timing of expenses and income (monthly time-steps), and the probability that flooding would occur in any one month (calculated from historic rainfall patterns). Where the period of inundation was deemed substantial, losses were assumed to include additional establishment costs, and losses in the net value of production.

The recently updated estimates of flooding losses that have been included within the F-RAM are shown in Table C-4. While not stated in the Comprehensive Study, it was assumed that the trigger point for “substantial inundation” was five days or greater.

Assumptions: The assumptions for assessing damages to agriculture are summarized in Table C-4.

Table C-4 Estimated Agricultural Losses

	Weighted, Average Annual Damages	Establishment Costs	Land Cleanup & rehabilitation	Total <5 d)	Total (>5 d)
Corn	$48	$0	$246	$293	$293
Rice	$227	$0	$243	$471	$471
Walnuts	$585	$5,284	$243	$828	$6,112
Almonds	$1,618	$3,514	$243	$1,862	$5,376
Cotton	$301	$0	$246	$547	$547
Tomatoes	$1,015	$0	$235	$1,250	$1,250
Wine Grapes	$3,241	$3,240	$235	$3,476	$6,716
Alfalfa	$250	$246	$243	$493	$739
Pasture	($15)	$82	$272	$257	$339
Safflower	$164	$0	$241	$405	$405
Sugar Beets	$313	$0	$262	$575	$575
Beans	$111	$0	$246	$356	$356
Other	$0	0	$246	$246	$246

Source: Comp Study

Estimating Flood Damages Associated with Infrastructure

Bridges and sections of roads can be washed away during flood events and most published estimates of flood damages to roads are dominated by these items. However, some damages to road pavement and bridge foundation do not become evident until considerably after the flood event.

The intrusion of water under pavement has long been recognized as affecting pavement life and durability. Excessive moisture in road pavements leads to deterioration in the durability of roads, and causes effects similar to a large increase in heavy vehicle traffic. In the severest cases, pavement life may be reduced by three-quarters (Bugden 1997).

The following are general maintenance issues with the failure of roads caused by flooding.

- Weakening of pavement as subgrade wets up
- Rapid potholing and seal loss following seal cracking
- Accelerated aging of bitumen

Approach: The F-RAM uses a single estimate of the damage to different road types inundated that includes the initial repair costs and the subsequent additional maintenance costs. Depth is less relevant in estimating damage costs; however, velocity and allowing the wetted pavement sufficient time to dry out before re-introducing traffic are extremely important.

Assumptions: The assumptions for assessing damages to roads are summarized in Table C-5. These data are preliminary, and should be updated as better information becomes available.

Table C-5 Estimated Damages to Roads

Type of Road	Cost of Damages $/mile
Cost per mile of highway inundated	$250,000
Cost per mile of major road inundated	$100,000
Cost per mile of minor road inundated	$30,000
Cost per mile of gravel road inundated	$10,000

Estimating Indirect Costs associated with Flooding

Indirect damages include the emergency responses to floods, as well as the disruption to normal social and commercial activities which occur subsequent to the direct damage of physical assets as follows:

- Emergency response including food and accommodation
- Health impacts
- Disruption of employment, commerce, transport and communication

Approach: Many of the components of indirect costs pertain to emergency food and accommodation in the post-flood period and as such are directly related to the population density in the inundated region.

Transport services are an important component of a functioning society and economy, and disruptions to these services impose an economic cost on society. The loss of transport services as a result of floods imposes economic costs in the form of lost time, or additional transport costs.

Flooding can cause health impacts for people in both direct and indirect ways. During flooding events, physical symptoms such as injuries and even death can result due to coming into contact with deep or rapidly flowing floodwaters. Flooding events can also cause emotional or psychological problems such as stress, exhaustion, nightmares, depression, despair, etc. The economic impacts of health issues manifest in medical costs and disruption to work activities.

The development of standard values for the various different categories of indirect damages is difficult. The overriding factor is the lack of available data, with which to formulate likely costs. Within the F-RAM, instead of using standard values for each category, we have chosen to represent indirect values as a proportion of direct values. There are a considerable amount of global literature that provides some basis and justification for using this approach.

Assumptions: The assumptions for estimating indirect costs are shown in Table C-6.

Estimating Total Damages for a Single Flood Event

The damages for a single flood are calculated as the probability of levee failure multiplied by the sum of losses to buildings, agriculture, roads, plus indirect losses.

Table C-6 Indirect Costs as a Percentage of Direct Damages

Type of Damage	Percentage of Direct Damages
Residential Buildings	25%
Industrial/Commercial Buildings	25%
Roads	50%

Other Unquantified Damages

Certain other estimates of damage are beyond the scope of this analysis:

- Loss of business to commercial and industrial enterprises
- Costs of flooding disruption to utilities (gas, electricity, water, sewerage, telecommunications and postal services)
- Potential for loss of life
- Disruption of tourism
- Costs imposed on public services, such as education and health services
- Damages to public gardens, and recreation assets